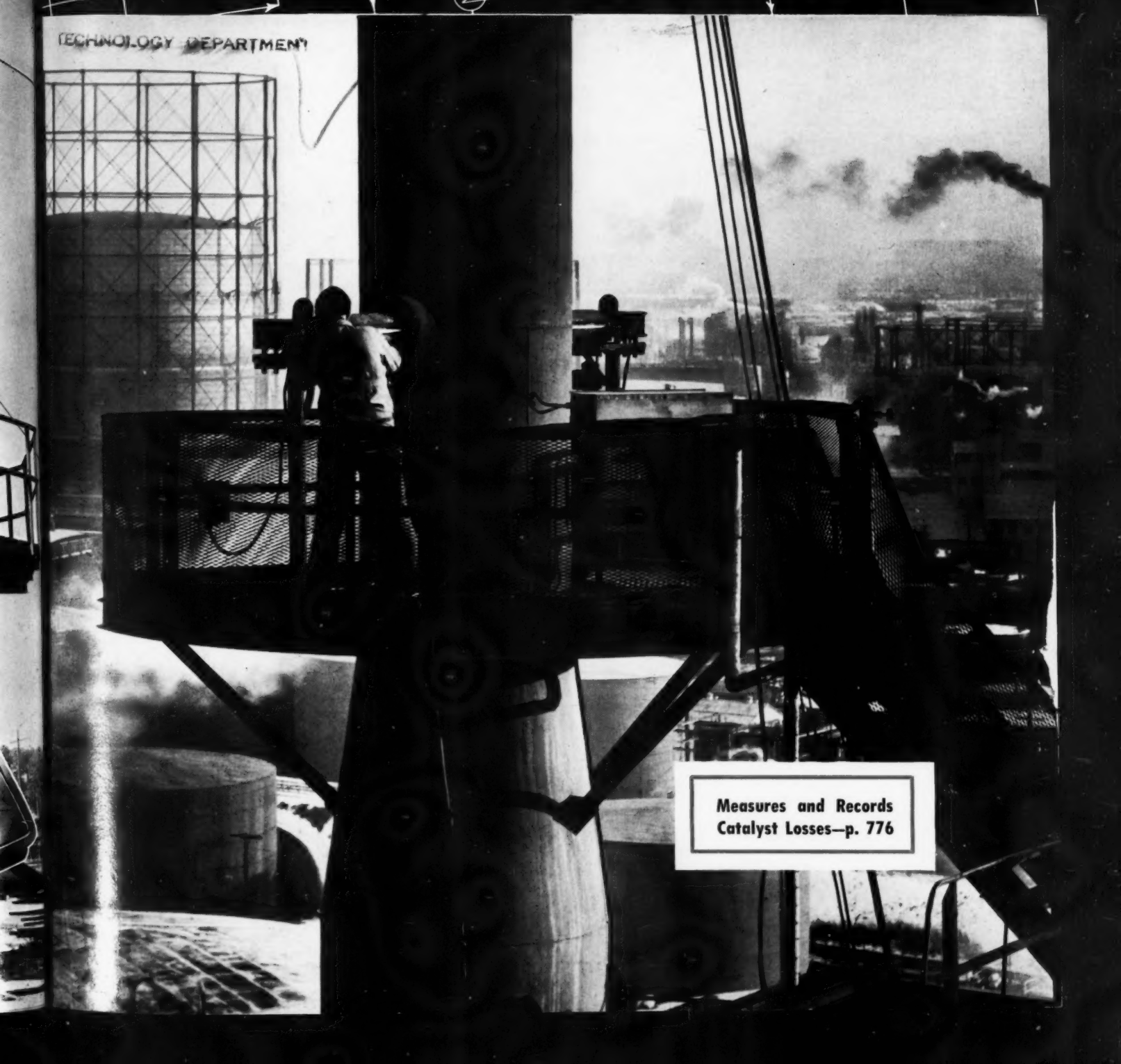
JULY, 1949
VOL. 4, NO. 7

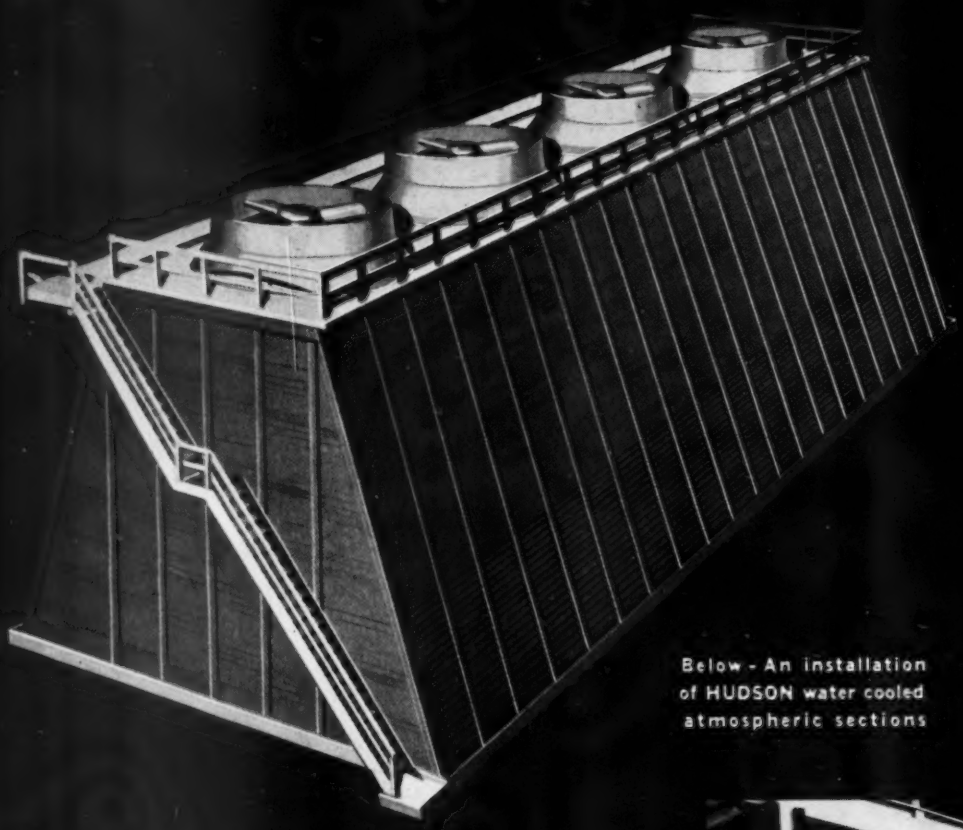
PETROLEUM PROCESSING



Measures and Records Catalyst Losses—p. 776

NEW HUDSON

Top Performance COOLING TOWERS



Below - An installation of HUDSON water cooled atmospheric sections

1 IMPROVED AIR FLOW AND AIR-WATER CONTACT

Unique deck design reduces air pressure drop and establishes positive counter current contact between air and water. Tapered sides of the tower eliminate dead space and decrease air turbulence.

2 LOWER OPERATING COST

Low pumping head and low fan horsepower result in perpetual power savings.

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FAIRVIEW STATION HOUSTON, TEXAS

ALCOA HEAT EXCHANGER TUBES

TECHNOLOGY DEPARTMENT

resist THE CORROSIVE BITE OF sour crude products

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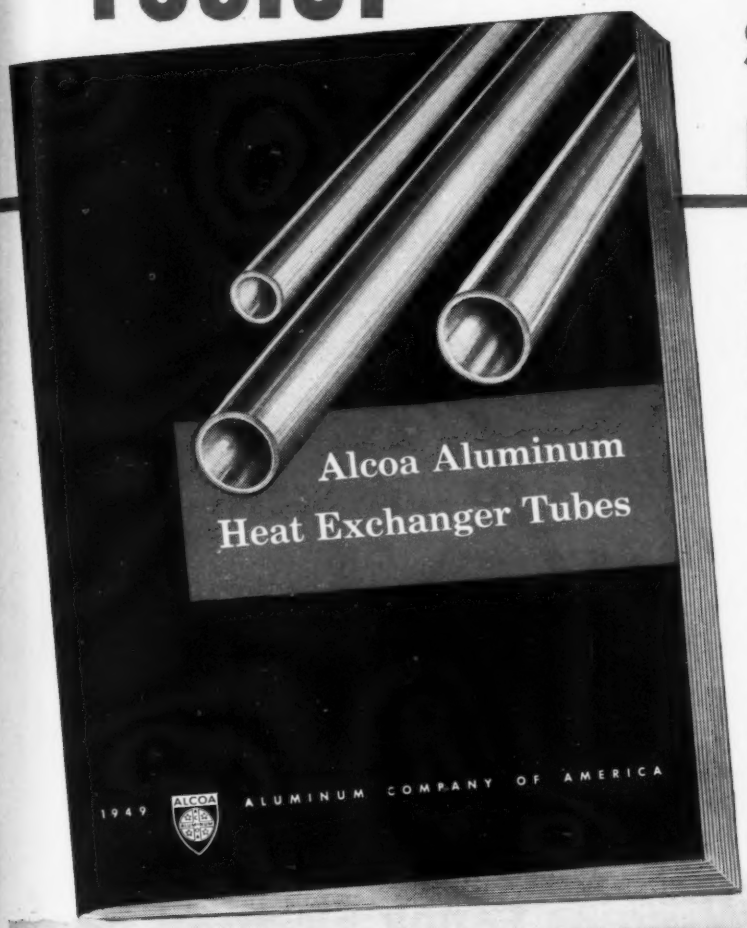
DETROIT



Install tube bundles of Alcoa Aluminum (A.S.T.M. Specification B234-48T) in your heat exchangers. They are unaffected by most refinery products including those of sour crude. Use Alcoa Alclad Tubes to resist most cooling waters. Installation is no problem. Use standard tools and procedures to roll-in.

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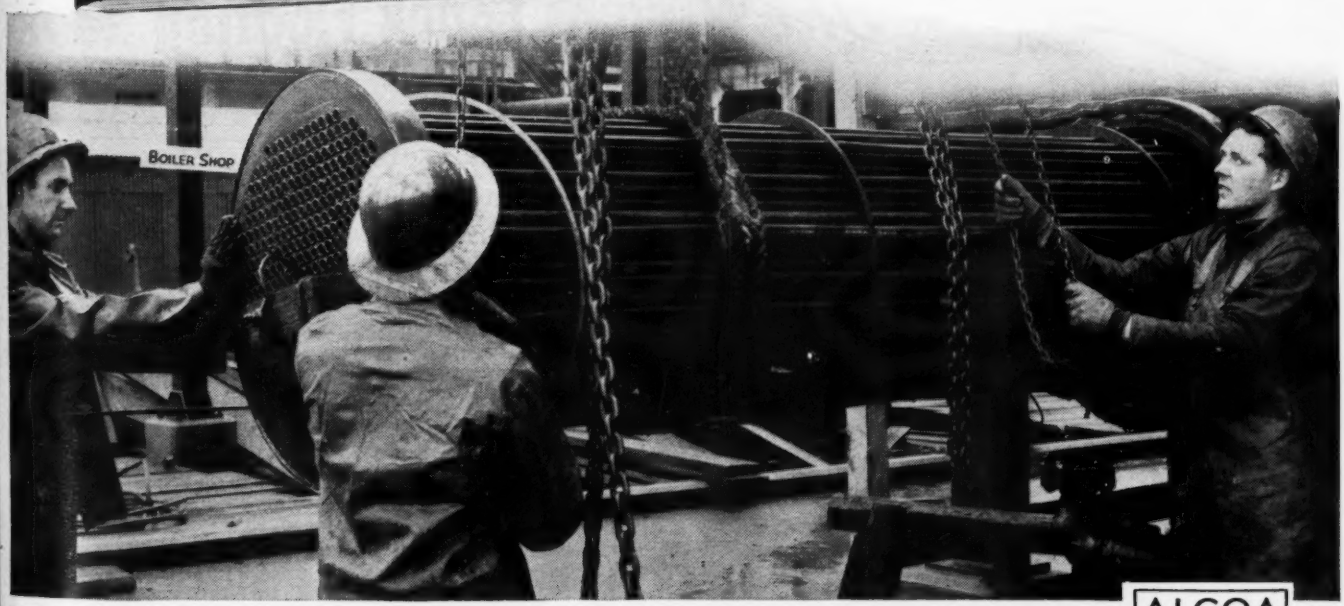

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Dry Seal Lifter Roof
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Lodek Floating Roof
Dry Seal Gasholder
Improved Balloon Roof

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. . . designed specially for the storage of corrosive oil products. The entire under surface being in complete contact with the tank contents, no vapors are trapped or can collect beneath the roof.

The basic exclusive conservation features of the Hidek Roof including the triple seal and extra large pontoons are retained.

Write for bulletin FR-3 which gives further details on Wiggins Lodek Floating Roofs.

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VOL. 4, NO. 7 JULY, 1949

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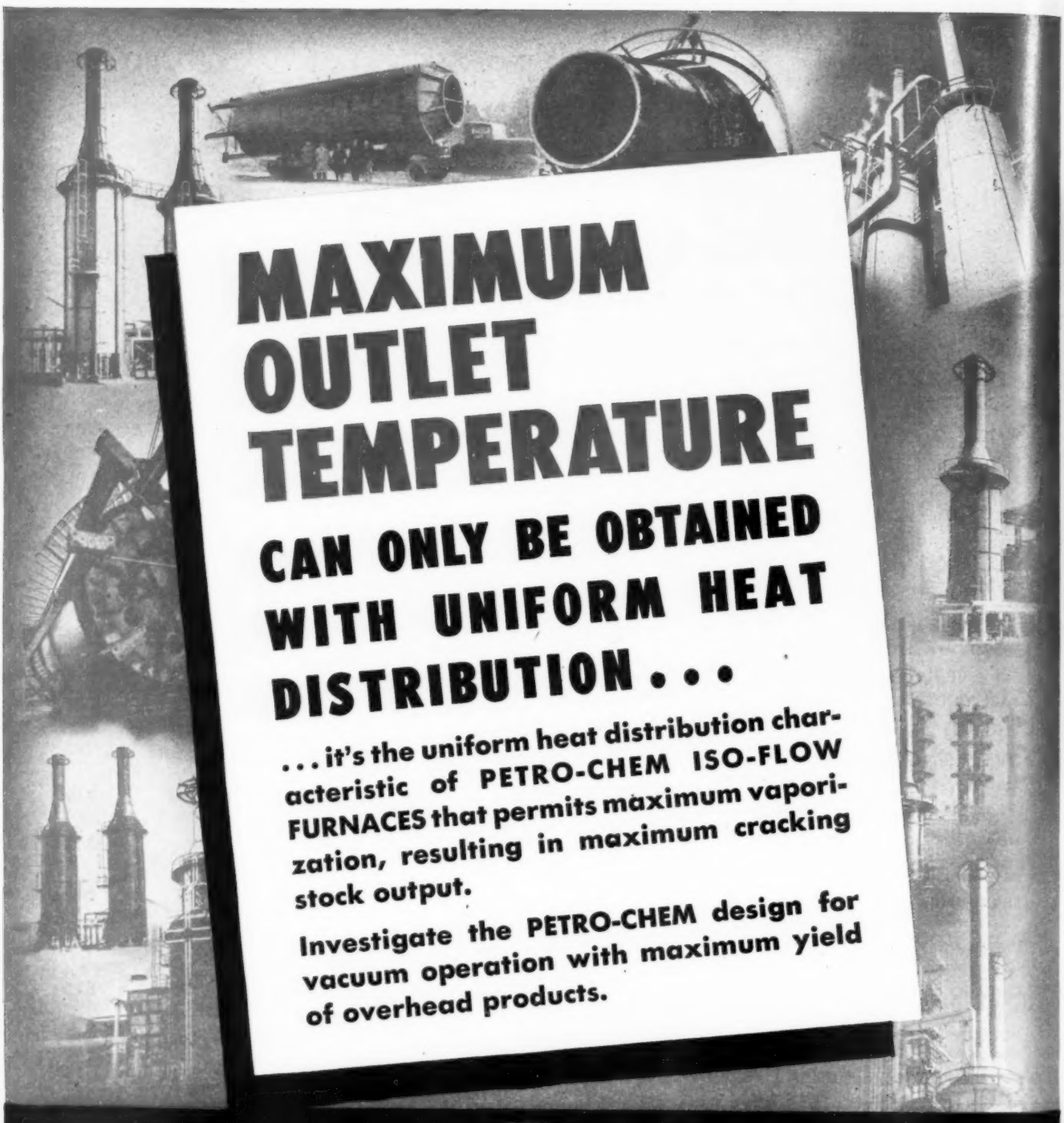
A daily independent oil-news reporting service issued from New York, Cleveland, Houston

NATIONAL PETROLEUM NEWS
The weekly oil marketing magazine, covering news, prices, transportation, storage, merchandising

PLATT'S OILGRAM PRICES
A daily independent oil-price reporting service issued from New York, Cleveland, Houston



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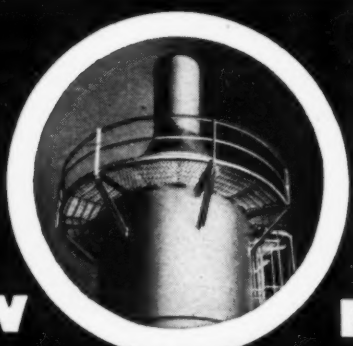

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Figure the PROFITS

When You Process Heavy Residues in the . . .

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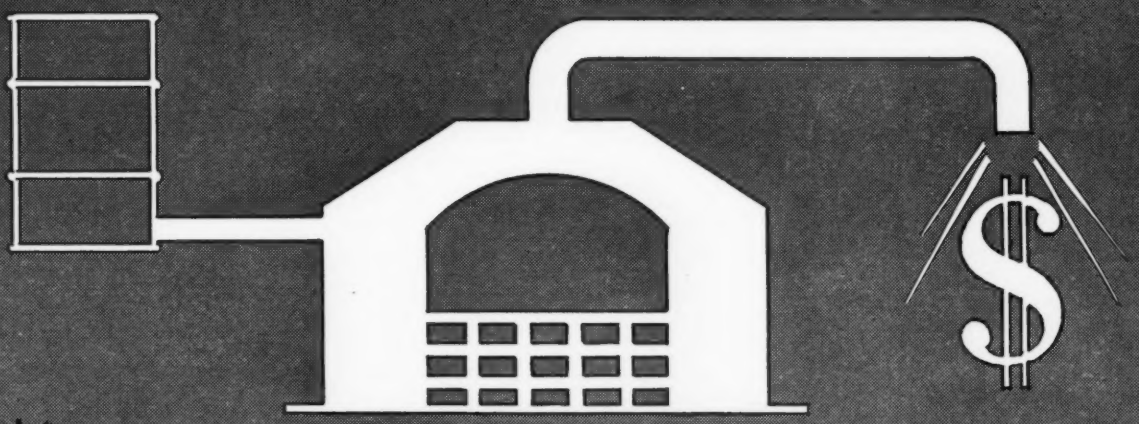

Example*

RESIDUUM Value: $800.00 + **The CURRAN** Carbonizing Process = **$2,432.00** (daily value)

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Current price of Residuum Oil,	approx. 80c per bbl.		10%	Gasoline by volume	100 bbls.
Current price of Crude gasoline,	approx. $4.00 per bbl.	1,000 bbls.	55%	Fuel oil by volume	550 bbls.
Current price of Fuel oil #3,	approx. $2.75 per bbl.	Residuum yields	15%	Coke	26 Tons
Current price of Coke,	approx. 20.00 per Ton		10%	Dry gas (1,000 B.T.U.)	

100 bbls. Gasoline @ $4.00 per bbl.	$ 400.00
550 bbls. Fuel oil @ $2.75 per bbl.	1,512.00
26 Tons Coke @ $20.00 per Ton	520.00
TOTAL DAILY YIELD	$2,432.00

★ The example cited, supported by actual figures based on current market quotations, indicates the profit possibilities of a specific residuum. Naturally, the character of your residuum will govern the value of the yields obtainable in your plant.

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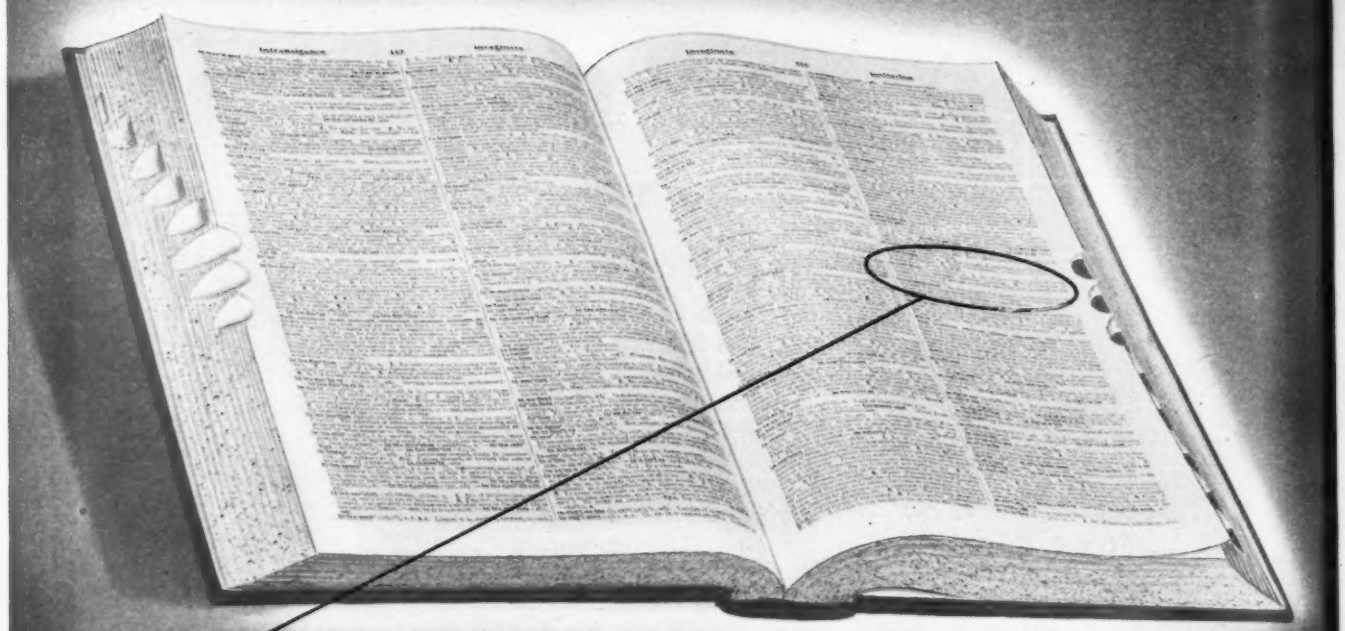

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Webster defines an investment as "the investing of money or capital for income or profit." In the heavy chemical field, Chemico is a proved translator of *investment* into profit. Here's why:

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Each plant is designed by engineers and technologists of recognized authority.

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Before deciding to build a new heavy chemical plant or remodel an old one, it will pay you to consult Chemico. CC 186

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What's Happening!

Important Current News Summarized for Refiners

EXPANSION

Over $2 billion has been earmarked by the oil industry for expansion and modernization during 1949, according to API President William R. Boyd, Jr. More than a fourth of this amount ($524,797,000) will go for increased and improved refining facilities, the API estimates, based on a recently-completed survey of capital investment plans for the current year.

Magnolia Petroleum Co. will construct a pressure maintenance plant near Alex (between Duncan and Chickasha), Okla., to compress 37,750 Mcf. of Chitwood field gas from pressures ranging from 0 to 1000 psi. to 4600 psi. for reinjection. Incidental liquid hydrocarbons resulting from the compression will be recovered. Delta Engineering Corp. and Magnolia made the engineering design; Construction Service Co. of Houston is contractor.

Phillips Chemical Co., Phillips Petroleum subsidiary, is doubling ammonia production capacity of its Etter, Texas plant and should be producing at rate of 140,000 tons annually within two months. Also being installed adjacent to the plant are facilities for making nitric acid; ammonium nitrate fertilizer equipment also will be installed nearby to produce 100,000 tons per year.

Shell Oil Co. will build a natural gasoline plant at Provident City, Tex., handling 60,000 Mcf. of gas daily, producing 2400 b/d of liquid products. Fluor Corp., Ltd., is the contractor.

• • •

PRODUCTS, SPECIFICATIONS

Research instead of Motor Method of determining octane number will be basis of rating Ethyl brand of gasoline effective Sept. 20. At that time, the Ethyl Corp. has notified refiners using its trademark, the minimum standard for "Ethyl" gasoline will be 86 octane by the ASTM Research Method, instead of the present 78 octane by the Motor Method.

In certain high-altitude states—Montana, Idaho, Wyoming, Nevada, Utah, Colorado, New Mexico and the extreme western sections of Oklahoma and Texas—the new minimum standard will be 83.0 octane number, Research Method.

One reason given by Ethyl for the switch was that its studies have confirmed the findings of other laboratories that ratings obtained by Research Method "are more satisfactory indices of performance on the road, particularly in the case of automobiles manufactured since the war."

Requirement of 10% minimum aromatics content for Grade 100/130 aviation gasoline will be dropped by the Air Force effective Jan. 1, 1950. Reason for change, AF explained, is that an improved synthetic rubber capable of withstanding the effect of alternate use of aromatic and non-aromatic fuel has been developed for aircraft fueling systems.

A new aviation gasoline for personal planes is now being marketed by California Standard. The new fuel is designated Chevron Aviation Gasoline 80/87 and has a controlled take-off antiknock rating, a quality the company states has been specified in the past only for higher octane commercial and military grades of avgas. It replaces the former Chevron Aviation Gasoline 80.

• • •

SYNTHETICS

Survey of possible sites for synthetic liquid fuel plants in 37 states and Alaska will be made for government by Ford, Bacon and Davis, Inc., of New York City, the firm which made a sample survey on the same subject in portions of three states in June, 1948. Contract, for $1,341,637, was awarded them last month by Army Engineers, acting for Interior Dept.

Current survey is expected to be completed in about 18-20 months, and will be directed at determining general areas suitable for synthetic fuel manufacture, based on such factors as availability of raw materials in sufficient quantity and quality, water supply, power, transportation, labor, housing and markets. Survey is not intended to select specific sites for construction of synthetic plants, or to determine total reserves of coal, oil shale, natural gas, or oil-impregnated deposits.

States to be included in survey are Alabama, Arizona, Arkansas, California, Colorado, Georgia, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, Montana, Nebraska, Nevada, New Mexico, New York, North Carolina, North Dakota, Ohio, Okla-

Information on these pages is obtained through the nation-wide news coverage services of PLATT'S OILGRAM NEWS

homa, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia and Wyoming.

"Full principle and policy support" to the original McCarran synthetic fuels program bill (S.6) has been given by the National Military Establishment. Bill aims at promoting construction of commercial size synthetic liquid fuel plants, either by industry with government assistance, or by government itself.

NME conditioned its endorsement, however, by saying the military "does not favor at this time any government support . . . beyond nucleus stage as long as American oil industry continues to meet demands from natural petroleum."

Advanced stage of construction of Carthage Hydrocol's synthetic plant at Brownsville, Texas, is indicated in a recent announcement that work has started on a 65-mile pipe line to the plant from gas fields in San Salvador. The line, being built by H. B. Zachry Co., San Antonio, at an estimated cost of $1,800,000, is intended to be complete about the middle of August, and, the company states, will allow preliminary tests to be made then of plant's operating equipment. Completion of the entire plant is still set for Jan. 1, 1950.

• • •

MARKETS, PRICES

Dominating oil markets throughout June was the question of future trend of crude prices in the Southwest and Mid-continent. Sentiment appeared to strengthen that prices generally would hold at current levels, at least until fall, with perhaps further adjustments in some heavy crude producing fields before that time.

However, the uncertainty slowed open market trading to a snail's pace in virtually all refined products. Gasoline shipments against contracts were heavy, but buyers appeared to require little over and above their contract commitments.

Price protection plans offered to heating oil customers by major suppliers generally in the East and by some in the Midwest thus far have failed to have the desired results—large volume movement of product from primary to secondary storage. Refinery stocks of light fuels remained top-heavy. Esso Standard Oil Co. pointed to this in announcing a 15% reduction in takings of crude for its Baton Rouge plant, one of the country's largest.

Highlights of the month price-wise were: Reversal of the downward trend in Penna. grade crude prices which has been underway since last December. South Penn and other leading buyers boosted their postings in amounts ranging from 13 to 16c/bbl., with top-grade crude at $3.40/bbl.

An 0.5c rally to 5.5c/gal. in Group 3 price for Grade 26-70 natural gasoline. Price had dropped from post-war high of 8.5 to 5c in the six weeks from Feb. 1 to March 14 of this year.

New low price of 60c/bbl. for heavy fuel in Oklahoma with some refiners at the same time posting just double that price.

Firming of heavy fuel prices at the Gulf with a 5c increase to $1.20/bbl. in the low reported cargo price for Bunker "C".

• • •

LABOR

Welfare clauses will receive greater emphasis in future negotiations by the Oil Workers International Union—if the new contract conditionally agreed to late last month by Sinclair Oil Corp. and OWIU officials is any indication. Sinclair's contracts in the past have been used by OWIU as its springboard to contract negotiations throughout the oil industry, since Sinclair makes a nationwide contract.

According to the terms of the new agreement, wages are left to local-level treatment of any inequities which may be brought up. By its chief welfare clauses it opens the door to negotiation of a shorter work week (OWIU recently came out in favor of reducing the standard work week to 36 hours), and sets in motion an inquiry into possibilities for a pension plan. In addition, the agreement is said to call for liberalized vacation privileges and sick benefits.

Pensions of $100 a month for workers on retirement at age 65 are being sought by OWIU, O. A. Knight, union president, revealed in Los Angeles just about the time the Sinclair agreement was announced.

• • •

TRANSITION

Dr. Walter Miller, 68, retired vice president of Continental Oil Co., died at his home in Ponca City, Okla., June 8.

Standard Oil Co. (Indiana) celebrated its 60th anniversary last month. The company was incorporated in Indiana June 18, 1889, and built the Midwest's first oil refinery in the sandy wastes at Whiting, in an area which is now a major refining center.

California Refining Co. says its 1300 b/d asphalt plant at Perth Amboy, N. J., may be out of operation until next April as result of explosion and fire which swept plant June 23, when a 500 bbl. storage tank was demolished, several others were damaged, and three employes lost their lives fighting the fire.

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by Dowell Service

The water sides of fifteen tube and shell condensers in a West Texas refinery were almost plugged by heavy scale deposits. Dowell was called in to clean them. After a six hour soaking with specially selected Dowell solvents, they were flushed out and returned to service. Following this chemical cleaning, gasoline left the condensers 20°F cooler than after a previous mechanical cleaning. *The improvement in operating economy paid for the job in 12½ days!*

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Experienced Dowell engineers do the job. They bring the essential equipment — truck-mounted tanks, pumps, heaters, and chemical proportioners — to make possible step by step control of the work. Call the nearest Dowell office for fast, practical and economical removal of scale and sludge from all types of heat exchange equipment, steam generators, water lines and water wells. Free cost estimates gladly given.

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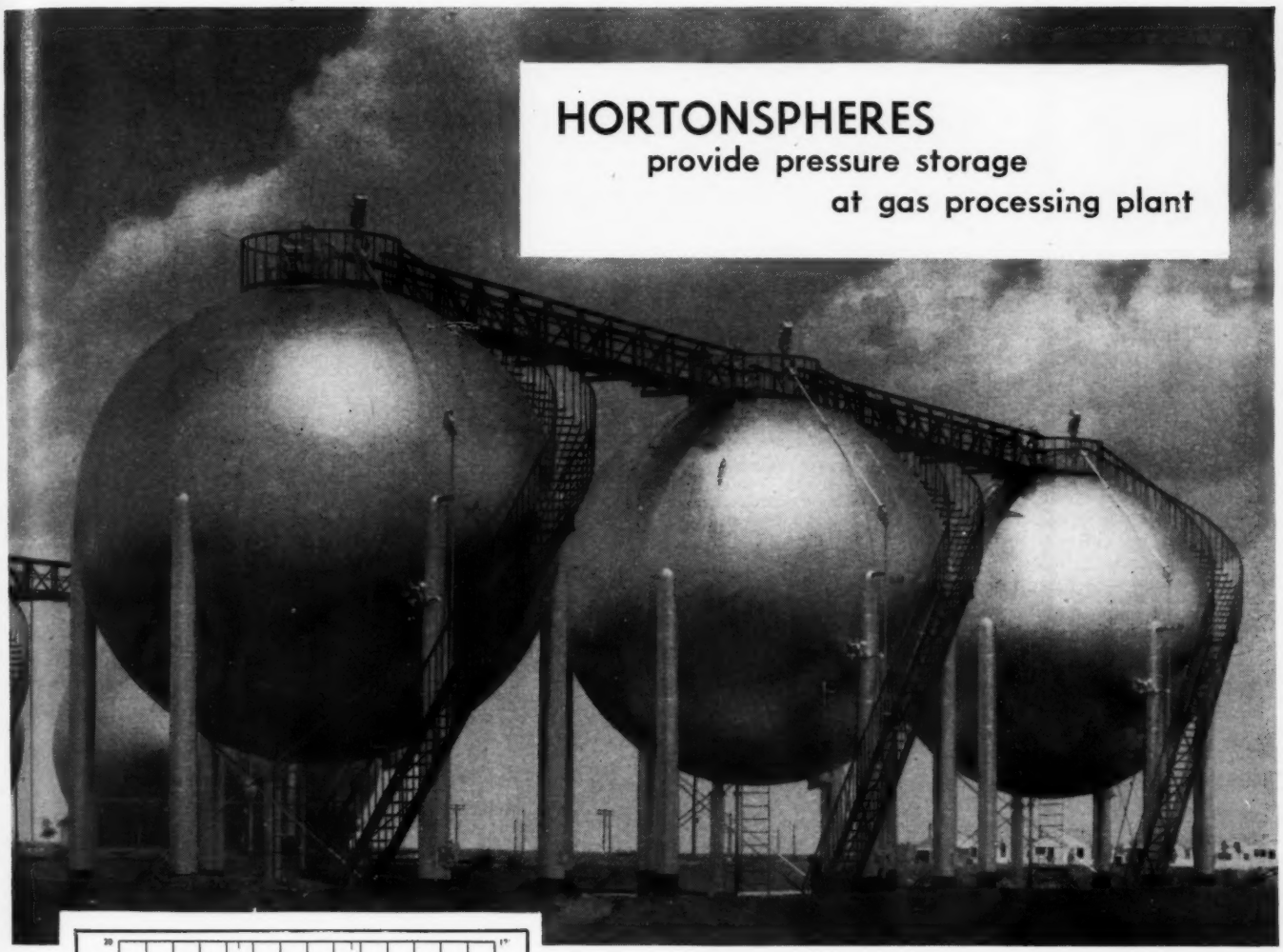
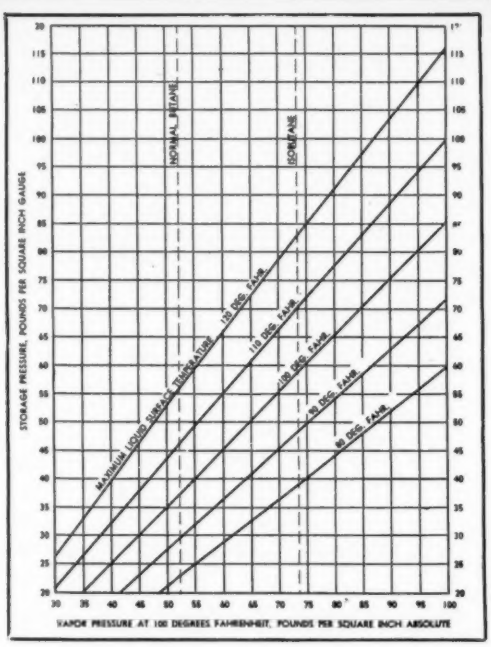
USS "OILWELL"

UNITED STATES STEEL



HORTONSPHERES
provide pressure storage at gas processing plant


STORAGE PRESSURE, POUNDS PER SQUARE INCH GAUGE
VAPOR PRESSURE AT 100 DEGREES FAHRENHEIT, POUNDS PER SQUARE INCH ABSOLUTE
NORMAL BUTANE
ISOBUTANE
MAXIMUM LIQUID SURFACE TEMPERATURE
130 DEG. FAHR.
110 DEG. FAHR.
100 DEG. FAHR.
90 DEG. FAHR.
80 DEG. FAHR.

THE three 2,500-bbl. Hortonspheres shown above are used to store finished products at the TXL plant, Notrees, Texas, which is owned jointly by the Shell Oil Company and the Texas Company. Every day this plant processes 50,000,000 cu. ft. of casing-head gas. Liquid products recovered consist of about 65,000 gals. of 26-lb. R. V. P. natural gasoline, 40,000 gals. of mixed butanes, and 39,000 gals. of pure propane.

Hortonspheres are recommended for storing volatiles like these because they are dependable and economical in operation. They prevent breathing and boiling losses and reduce or eliminate filling losses depending on volatility and the pressure at which the spheres operate.

This chart shows how to determine storage pressures required for products you are handling. Locate the vapor pressure of the liquid to be stored at the bottom of the chart. Draw line vertically until it intersects the maximum surface temperature line. Then read storage pressure required in lbs. per sq. in. at the right or left-hand side of the chart.

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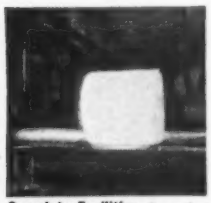

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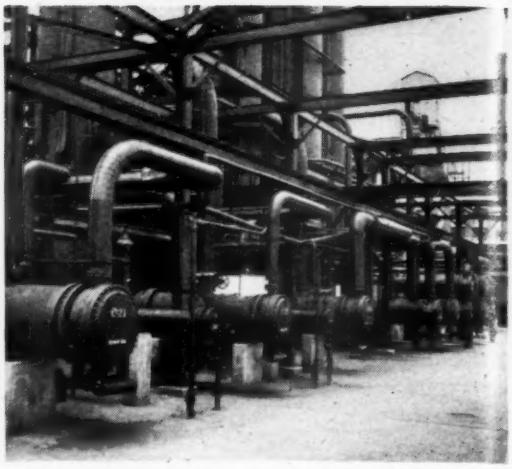

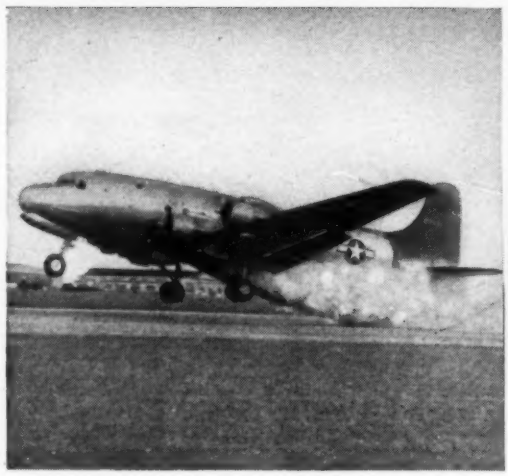

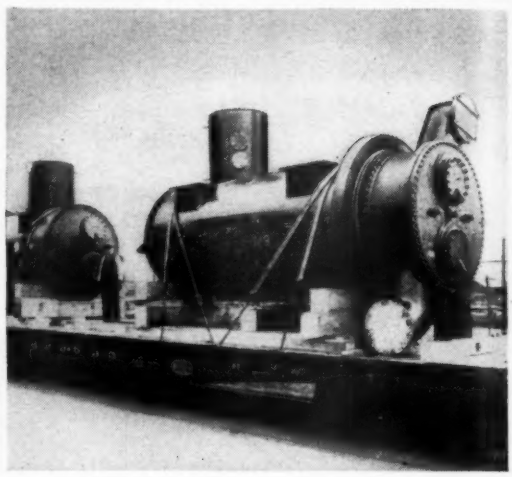

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Tomorrow

. . . IN PETROLEUM TECHNOLOGY

By B. H. WEIL, Atlanta, Ga.
Editor, "Monthly Summary of Industrial Developments"

Brief reviews of currently reported technological and economic developments, in the light of their potential bearing on petroleum refining

Storage of Natural Gas Is Still Major Problem

ALONG WITH THE GROWING USE of natural gas in cities far from abundant gas fields has come the problem of economic storage of sufficient quantities to meet peak loads. Numerous stratagems have been employed—storage in depleted gas and oil fields, liquefaction and storage in liquefield form, supplementation with propane-air mixtures and "catalytically reformed" LPG's, etc. Each of these methods has its own merits and demerits, some of which have been mentioned in this series before.

It has long been known, also, that natural gas could be "stock-piled" on solid absorbents at reduced temperatures on the order of −250° F. However, this method has recently been brought to the fore by C. V. Spangler, of J. F. Pritchard & Co., who reports that Fuller's earth appears to be the most satisfactory adsorbent and that it has been found that one cubic foot of this material (bulk density, approximately 35 pounds) will adsorb about 200 cubic feet of methane at −250° F. and 800 mm. of Hg.

On this basis, the storage of 50,000,000 cubic feet of methane would require approximately 250,000 cubic feet of Fuller's earth. Spangler points out that this volumetric requirement is not too unfavorable when compared with the 97,000 cubic feet which would be occupied by the liquefied methane equivalent (were liquefaction to be used), and he states that, at present, the process's basic economics are of the same order as those of methane liquefaction. He makes the definite statement that the chief advantage of storage on adsorbents is the much greater safety of this process when compared with methane liquefaction.

The "dangers" of the latter process do not seem to have ruled out its further use, however. Late in May, the Peoples Gas Light & Coke Co. asked the Illinois Commerce Commission to permit it to lend its subsidiary, Chicago District Pipeline Co., $6,000,000 to build a gas liquefaction and storage plant between Joliet and Chicago, in order to help it better to meet Chicago's peak winter gas load. This plant, scheduled for operation by the winter of 1950-51, will have a capacity of 400,000,000 cubic feet of natural gas (liquefied equivalent).

Growing distribution of natural gas by public utilities poses many problems of interest and importance to the petroleum industry, technical aspects aside. Along with threats of Government regulation because of the inevitable close association of petroleum and natural gas production are the more interesting ramifications of the prospects of higher natural gas prices at the well, engendered by public utility use. Such higher prices, if they come, may complicate or eliminate the production of some "petroleum (natural gas) chemicals," carbon black, synthetic petroleum (via the Synthine process), etc. There is no question that the petroleum industry must regard natural gas production, distribution, storage, and use as associated with its own diverse operations.

New Petrochemicals Of Wide Applications

IT IS NO LONGER "NEWS" when a petroleum company announces it is entering into the production of chemical products from petroleum hydrocarbons, or when a chemical company reveals that it is producing such materials, but it is still worthy of attention when several such companies announce a variety of new petrochemicals in a short span of time. This has recently occurred.

One of these products is "Kenflex," a synthetic resinous material produced by catalytically condensing specific alkyl napthalenes. Produced by the Kenrick Corp. of New York, under license from the Socony-Vacuum Oil Co., Kenflex is said to possess unusual stability and low electrical loss, rendering it suitable for such uses as potting and caulking compounds, vinyl insulated wire, and electric cable fillings.

Another new petrochemical is Panarec-210, an oxidized hydrocarbon resin being produced in commercial quantities by the Pan American Refining Corp. Of petroleum origin, its lightness of color, solubility in hydrocarbons and other common solvents, and compatibility with drying oils, resins, and elastomers are said to render it of value in air drying and baking finishes, where it imparts high gloss, hardness, and alkali resistance.

Also of interest is the Barium Reduction Corp.'s new carbon bisulfide plant at South Charleston, West Va., since this plant employs a modification of a process developed by and licensed from the Pure Oil Co. In this process, natural gas and sulfur are catalytically reacted (in the vapor phase) to yield carbon bisulfide and by-product hydrogen sulfide; Barium Reduction, it is said, will employ the latter in the manufacture of its various sulfide products.

The Merichem Co., of Houston, is now producing three different boiling-range cresylic acid products: 183-205° C., 205-230° C., and 230-245° C. Spencer Kellogg & Sons, Inc., have announced two new base oils for paints and varnishes, produced by reacting linseed or soybean oils with petroleum-derived dicyclopentadiene. At its El Dorado, Ark., plant, the chemical division of Lion Oil Co. recently began full-scale operation of its $250,000 plant for the production of protective coatings ("mastics"). The Chemical Division of Koppers Co. Inc., is offering commercial quantities of isopropyl phenols; trimethylhexanol is being produced commercially by the ammonia department of du Pont; 2-ethylhexanol is now being manufactured by Tennessee Eastman; etc.

A year or two ago, when crude oil prices began their rise from wartime-frozen levels, harbingers of gloom foretold the end of the boom in the manufacture of chemicals from petroleum. It is clearly evident, now, that this is not yet in sight, although other economic factors than the price of crude oil have served to bring it closer.

Synthine Fats Not Proved For Human Consumption

DESPITE THE FACT that during the war edible fats and oils were produced in large quantities in Germany, from fatty acids derived from the Synthine process via oxidation of Synthine paraffin waxes, the Food and Agricultural Organization has recently declared that the overall picture is still not sufficiently clear as regards possible physiological effects of these fats on humans.

According to the FAO, German wartime use of these synthetic fats was considered a Nazi triumph, and the workers concerned tended to suppress unfavorable results. Pending

the collection of more complete and satisfactory clinical and experimental data, FAO considers it clearly premature to advocate large-scale manufacture of such fats for human consumption. However, since Germany is short of fats, FAO advocates the manufacture of such products there for industrial purposes.

Even if it is eventually decided that Synthine-based fats are not suitable for human consumption—a decision of only academic interest in peacetime to a country such as ours —it is still highly likely the component Synthine fatty acids involved will eventually be produced in this country on a commercial scale unless the price of natural oils and fats drops too far. The oxidation of petroleum waxes for production of fatty acids has long been under study here, and this knowledge plus that gained in Germany should eventually lead to domestic production of fatty acids from Synthine waxes when the latter become available in this country.

Economics Bearing Down On Synthetic Rubber

THE FORTHCOMING PRODUCTION of some 200,000 tons per year of "cold rubber" will by no means end the problems of synthetic rubber producers, according to recent developments. A world over-supply of elastomers has deflated natural rubber prices to a point where this substance now costs less on the U. S. market than does GR-S, and this over-supply threatens to become worse instead of better within the next few years.

It appears generally agreed that Congress must pass long-term legislation requiring the use of minimum percentages of synthetic rubber if natural rubber is not to under-price synthetic off the market. Such a development, if it meant permanent closure of synthetic rubber plants, would later enable the rubber cartel to again set its own prices. Incidentally, P. W. Litchfield, chairman of the Goodyear Tire & Rubber Co., recently pointed out that the existence of the postwar synthetic rubber industry saved American consumers $2,000,000,000 through stabilization of natural rubber prices between April 1, 1947, and Jan. 1, 1949, since Litchfield believes the price of rubber would have gone to $1 per pound or more if the synthetic rubber industry had not existed.

For 1949, the Rubber Study Group (London) has estimated that world production of natural rubber will be 1,575,000 long tons, while the world consumption of natural and synthetic rubbers is expected to be 1,450,000 and 450,000 long tons, respectively, exclusive of government stockpiling. U. S. consumption was estimated at 600,000 long tons of natural rubber and 410,000 long tons of synthetic rubber.

Since it is believed that world production of natural rubber may rise to 2,000,000 long tons per year within the next few years, rubber economists point out that such an increase of 400,000 long tons per year above present levels may present serious market difficulties unless new uses for rubber can be developed. One such new use — incorporation of natural or synthetic rubber in bituminous highway materials—is now under serious study in several parts of this country.

Incorporation of powdered elastomers in bituminous binders for road surfacing at an approximate rate of one-third to one ton per mile is under study in experimental highways in Texas, Virginia, and Ohio—one source even mentions use at a rate of 5-8 tons of natural rubber per mile and states that decreased maintenance costs offset higher material expenses.

"Cold rubber", on a quality basis, will apparently be able at least to hold its own with natural rubber unless prices for the latter remain disproportionately low, but it appears not at all unlikely that total GR-S production will continue to fall unless present price and supply trends are reversed. This does not bode too well for continued high-level production of butadiene from petroleum.

Toxicological Properties Of New Products Studied

AS PRODUCERS OF A WIDE VARIETY of products which find myriad uses, the petroleum refining industry has become increasingly aware of the necessity for toxicological studies of those of its products which have specific toxicity, in the interests of the public's safety.

Not every petroleum company, of course, can afford to maintain its own full-fledged toxicological laboratory, so that resort must often be made to consulting laboratories equipped for this purpose. However, it is interesting to note that one of the major producers of petroleum chemicals, the Carbide & Carbon Chemicals Corp., has for 12 years sponsored a Chemical Hygiene Fellowship at the Mellon Institute for the study of the physiological properties of its products.

As pointed out by Dr. H. F. Smyth, Jr.,(1) "it is seldom that the literature contains adequate toxicological data upon a particular chemical that is in the process of development. The lack is accounted for largely by the disproportion between the numbers of workers in the two fields (toxicology and chemical synthesis) ... Furthermore, one chemist can in a year make enough new chemicals to occupy the full attention of one toxicologist for a lifetime."

The situation, however, is far from hopeless, for "estimates based upon analogy are adequate for many chemicals with which human contact is unlikely to be intimate, prolonged, or often repeated." If such is not the case, however, toxicity studies using small animals are definitely required if the compounds "are destined for applications where human contact is likely or certain," and even human experiments are required for definitive answers.

Dr. Smyth points out in some detail the value of "range-finding tests" in protecting chemists at work on new products, eliminating further work on those of extreme toxicity, indicating possibilities of chemical modification to diminish toxicity, and (sometimes, since more elaborate studies are usually required) providing sales departments with knowledge of where and where not to recommend use of specific products. Many of the studies of Carbide & Carbon's Mellon Institute Fellowship are thus made on compounds which "will neither be sold nor used in the plant."

The range-finding tests developed by Smyth and his co-workers are designed to provide quicker, less expensive answers than full-fledged toxicological studies. When a chemist sends in a 10-gram sample, "we make some tests at a cost of perhaps $25 less than his sample cost. When we receive a pound from a bench-scale operation, we spend about $300. But, when a chemical in commercial production looks as if it would fill a need in food products, the sky is the limit. In this way we can test economically a large number of chemicals which will never be sold."

Details of such tests are not pertinent here. It must suffice to note Smyth's concluding statement:

"I can epitomize my discussion by citing the hypothetical instance of the manufacturer who decides he can spend $10,000 a year on toxicological study of new chemicals. For this he can obtain reasonably thorough studies of two products, or he can have one product studied by conventional methods and 20 in early stages of development assayed by range-finding methods. If he follows the latter course for a few years he should find such a reduction in development expenses, owing to early abandonment of hopeless compounds, that he will want to increase his toxicological budget."

(1) H. F. Smyth, Jr., "Range-Finding Tests: Toxicological Control in New Product Development," *Chemical and Engineering News* 27, No. 19, 1360-62 (1949).

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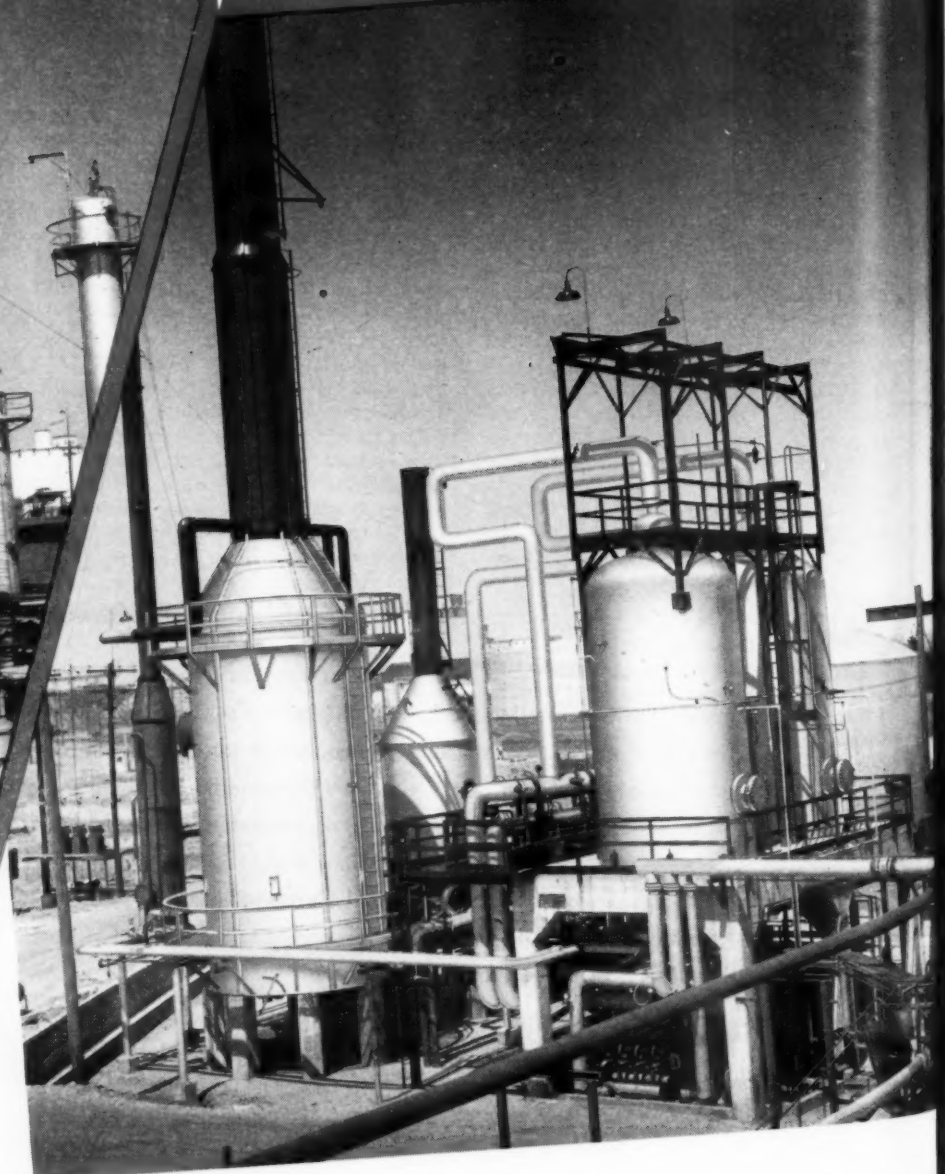

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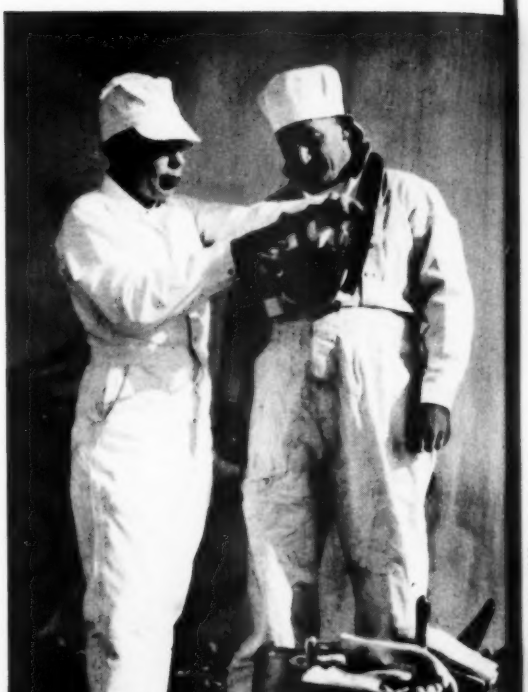

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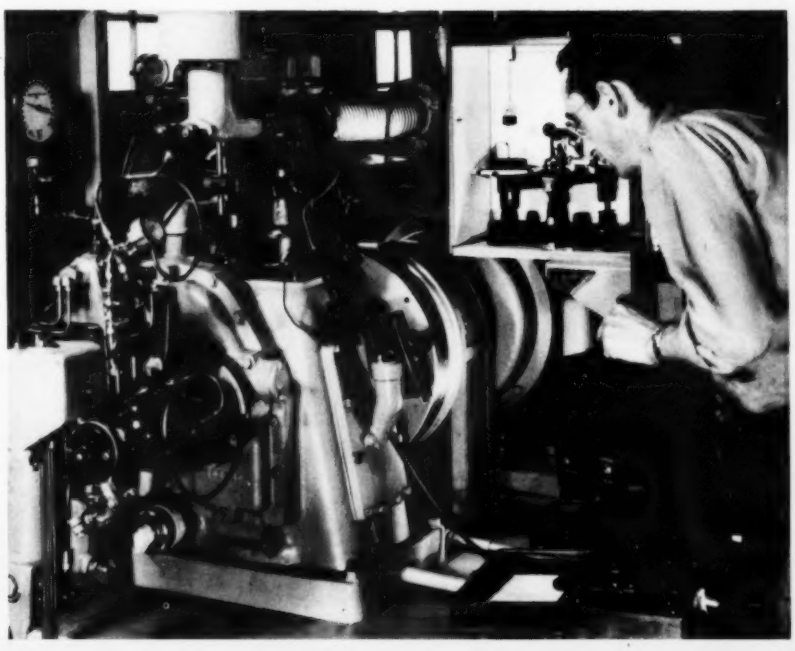

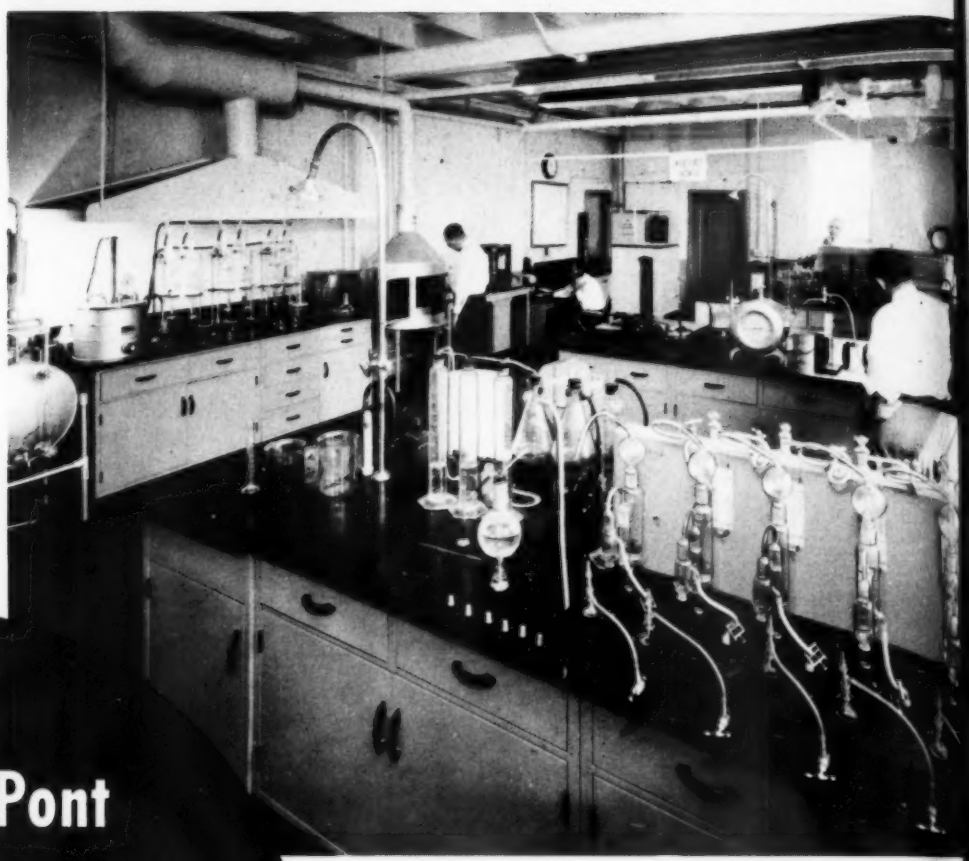

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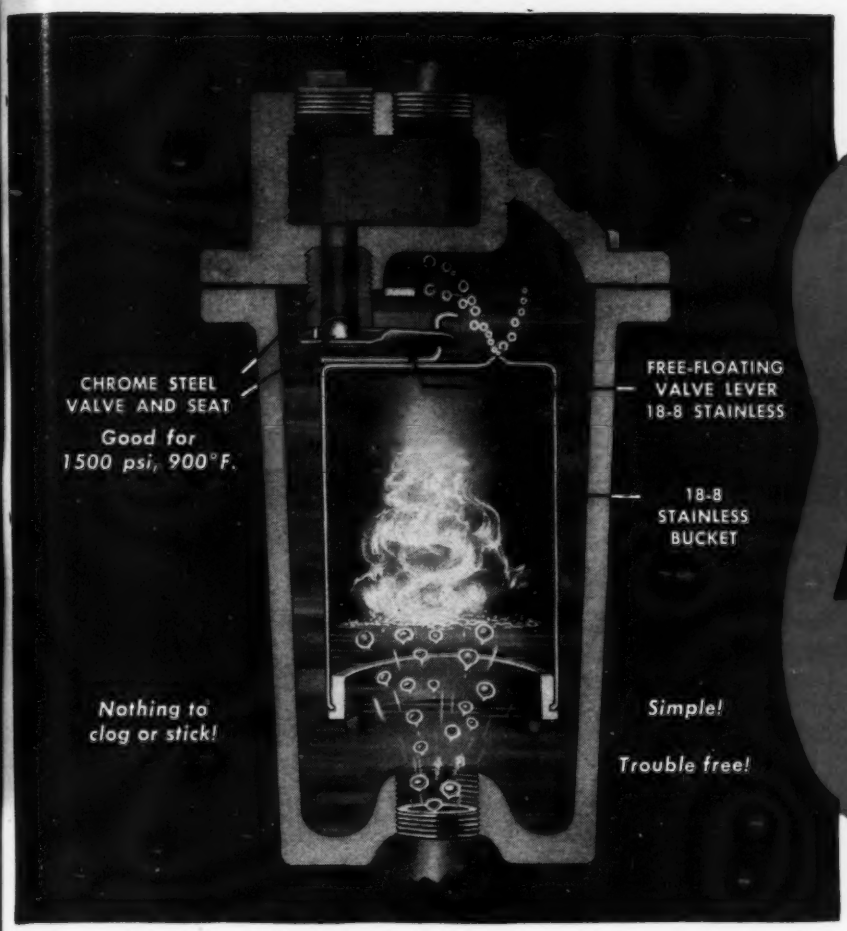

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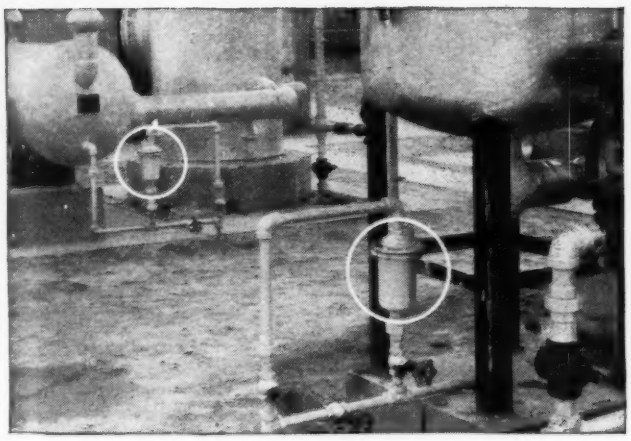

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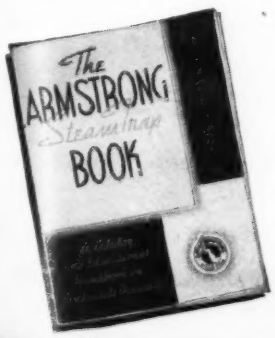

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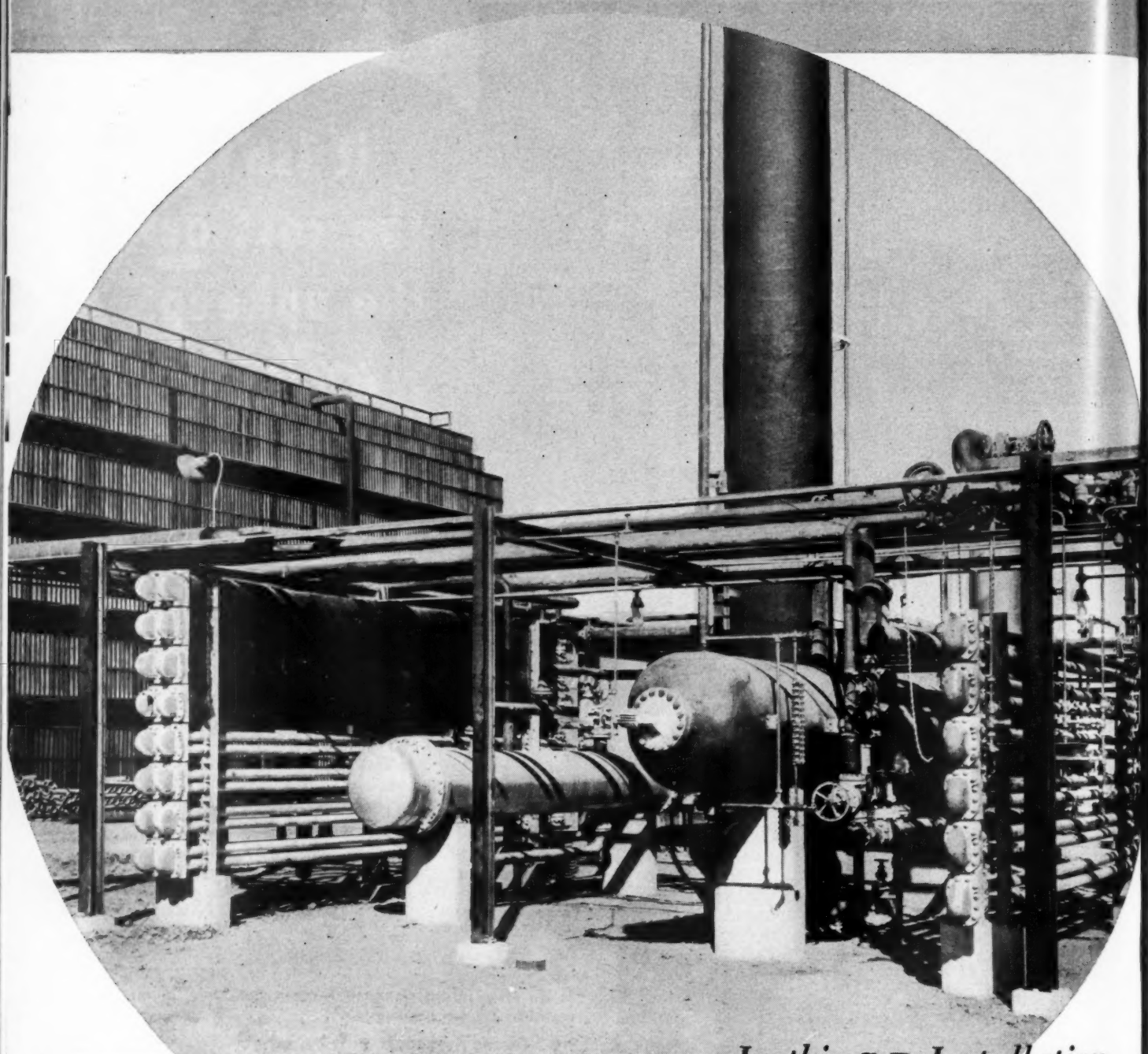

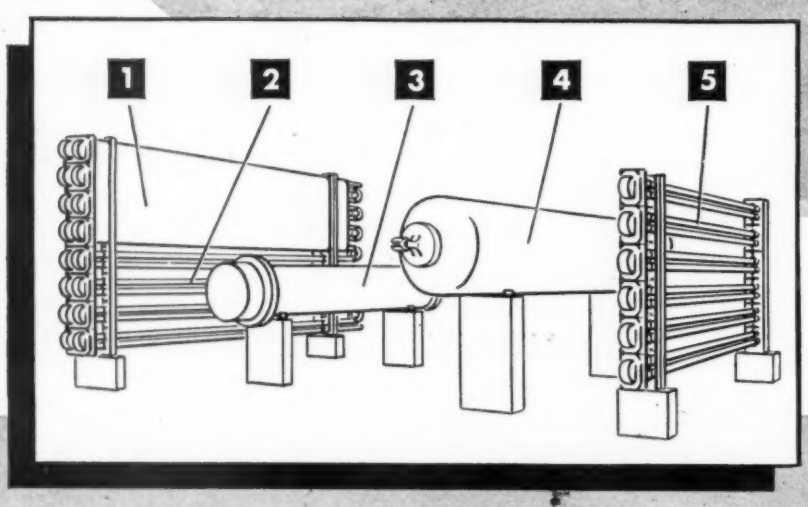

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GRISCOM-RUSSELL · PIONEERS IN HEAT TRANSFER APPARATUS

G-R

HEAT TRANSFER APPARATUS Fully Serves a Stabilizer In This Installation

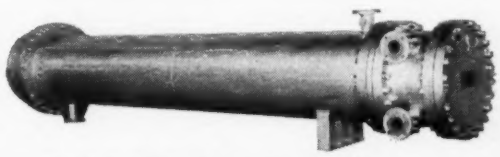
As shown in the illustration on the adjoining page, all the heat transfer apparatus required for the stabilizer at this representative refinery is of G-R design. The G-R units include cooler, exchanger, reboiler and condenser, and also naphtha side-cut cooler.

Many additional G-R units, not shown in the illustration, were also installed for other services here; for this refinery, like hundreds all over the country, standardized on G-R Heat Transfer Apparatus to assure most effective heat exchange and recovery throughout the plant.

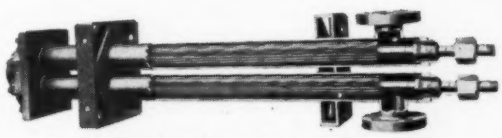
Whatever may be *your* heat transfer requirements . . . whether standard or special . . . investigate G-R designs. The unequalled range of G-R apparatus, including both finned tube and bare tube heat transfer surfaces, provides an exactly suitable design for every service. Write for descriptive bulletins on units for services in which you are interested.

THE GRISCOM-RUSSELL CO.
285 MADISON AVE., NEW YORK 17, N. Y.

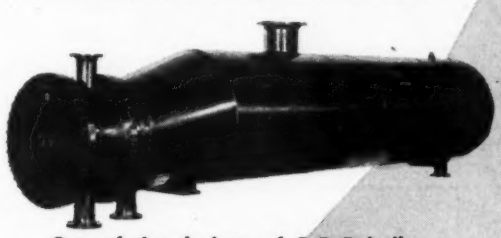
TYPICAL DESIGNS OF G-R HEAT TRANSFER APPARATUS



G-R Tubular Exchanger, available with many different designs of stationary and floating heads, and with exclusive service features



Sectional drawing of the G-R Twin G-Fin Section, the heat exchanger with a greater range of applications than any other design on the market



One of the designs of G-R Reboiler, available with bare tubes or K-Fin elements.

GRISCOM-RUSSELL

Where WeldOlet is attached to run pipe, it tapers at proper angles, providing for a single bevel groove joint at the crotch section, blending into a V-butt joint at the ear portion.

The quickest — most economical — way to insure FULL PIPE STRENGTH AT BRANCH CONNECTIONS

WeldOlets*, with outlet sizes from ⅛" to 24", both straight and reducing, need no additional reinforcement to establish and fully maintain original strength on ASTM A-106 Seamless Steel Grade A Pipe, as set forth in Code for Pressure Piping, American Standards Association, B31.1-1942, and Supp. No. 2, B31.1b-1947. WeldOlet welding fittings provide the quickest, most economical, most *satisfactory* method of obtaining *full pipe strength* at branch connections. For detailed engineering reference data, write for Catalog W-2.

BONNEY FORGE & TOOL WORKS

FORGED FITTINGS DIVISION • 368 GREEN STREET • ALLENTOWN, PENNA.

Authorized Canadian Factory Representative: Sterling Steel Co., Ltd., 20 Temperance St., Toronto 1, Canada—1040 Sherbrook St., W., Montreal, Canada

MANUFACTURERS OF FAMOUS BONNEY TOOLS

Fig. 1—Cut-away view of reducing size WeldOlet with welding outlet in place. The external rib and wide bases or footings of WeldOlets* eliminate the need for *extra supports* to take care of bending or vibrational stresses at crotch section, the point of greatest stress.

Fig. 2—Note blending of ear portion of welding fitting to run pipe. Extension of weld metal below inside scarfed portion of pipe insures all sections of joint greater than pipe wall thickness.

WELDOLETS

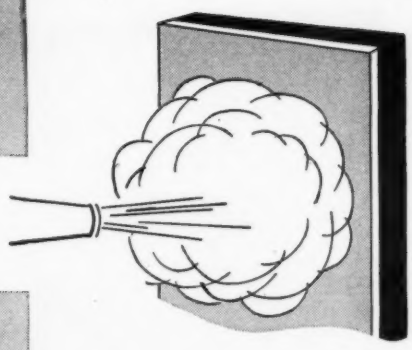
*Trade Mark Reg. U.S. Pat. Off. Pat. in U.S. & Foreign Countries

FOR WELDED BRANCH PIPE OUTLETS

When you want Bonney Welding Outlets, ask for WeldOlets*

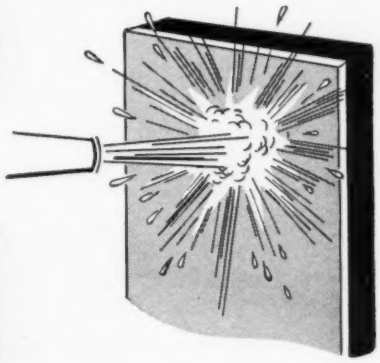
FIRST

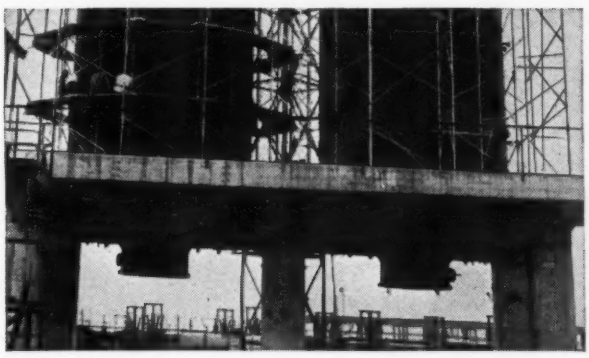
350° STEAM



THEN

60° WATER AT 1500 LBS.





Stainless-Clad Steel decoking tower of Cities Service Oil Company, East Chicago, Indiana, built by Chicago Bridge & Iron Company. Chicago, Ill.

"There has to be a bond to take that punishment"

A materials engineer for an oil refining company was telling why he insisted on a Lukens Clad Steel, with its permanent bond between cladding and backing plate, for their decoking tower.

"Even under those severe conditions, there will be no separation of the metals. We get protection of the equipment and our products from the clad surface, and the bond prevents corrosive materials from creeping in to attack the base metal."

You get this permanence of bond and uniformity of cladding in all Lukens Clad Steels—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad. Thus you can obtain the benefits of these *solid* corrosion-resistant metals with the economies possible with *clad* steels.

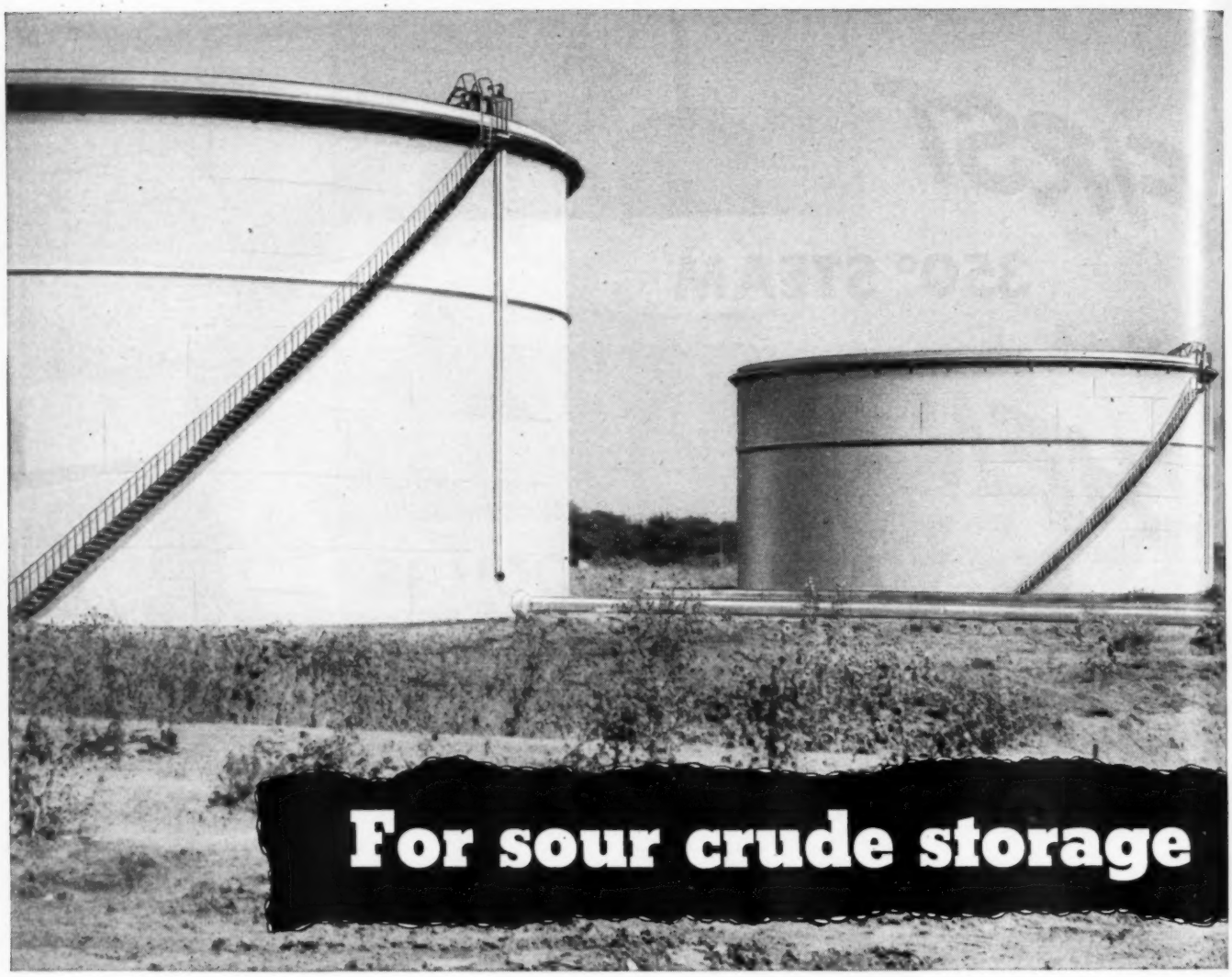
Lukens makes clad steel plate as wide as 178 inches, or as thick as 6 inches—all in the extra-smooth sodium hydride finish. Applications in the Petroleum Industry are described in Bulletin 461. For a copy, write Lukens Steel Company, 443 Lukens Bldg., Coatesville, Pennsylvania.

CLAD METAL STEEL

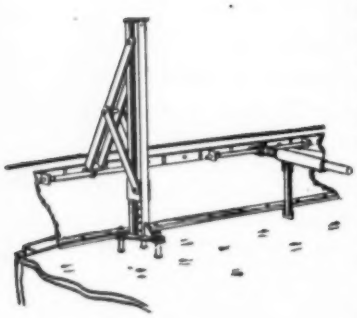
LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY



GRAVER FLOATING ROOF TANKS END CORROSION—END FILLING LOSSES



Corrosion and filling losses . . . these are the problems that complicate the storage of sour crude. To meet these problems efficiently and economically, Graver offers an improved Floating Roof with Full Double Deck. Check these advantages:

SEAL maintains full contact with tank shell at all points to prevent the escape of valuable vapors. All filling losses and up to fifty percent of standing losses (compared with cone roof tanks) are eliminated.

CONTACT is complete between under side of roof and surface of stored product. There are no pockets where vapors can collect and allow corrosion.

COMPLETE DOUBLE DECK provides a dead air space which adequately insulates the product and prevents boiling.

SHOE wear is reduced to a minimum by an exclusive flexible hangar mechanism which holds the seal "gently" against the tank shell.

The Graver Floating Roof with Full Double Deck is available for tanks of *all* capacities. Write today for details and recommendations on the solution of your sour crude storage problem.

GRAVER

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA.

There's good news in this important

Announcement

about

"MONEL" Heat Exchanger Tubing

Call your nearest Distributor!

J. M. TULL METAL & SUPPLY CO.
Atlanta, Ga.

WHITEHEAD METAL PRODUCTS CO., INC.
Baltimore, Buffalo, Cambridge, Newark, New Haven, New York, Philadelphia, Rochester, Syracuse.

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Get IMMEDIATE DELIVERY on Monel heat exchanger tubing!

Now you can get Monel* heat exchanger tubing—*at once!*

There is a stock of ¾" OD x 0.065" and 0.083" wall x 16' long Monel tubing in the Houston warehouse of METAL GOODS CORPORATION.

Orders are now being accepted by Distributors (see complete listing at left) for *immediate shipment* from warehouse stock.

This means you can quickly put Monel heat exchanger tubing to work in all those places where corrosive conditions are causing delay, expense or shut-down.

Monel brings you high resistance to the destructive attacks of such corrosives as hydrogen sulfide, hydrochloric acid, sulfuric acid, and brine.

Monel also withstands hydrofluoric acid in HF alkylation, and serves dependably under high temperature, high pressure conditions in feed water heaters. It stands up in caustic soda reboilers and in condensers for chlorinated solvents and furfural.

In condenser tubes where it meets impure or brackish waters at high velocity, Monel resists the effects of cavitation and impingement.

And here's something else. Monel is strong and tough, yet it can be readily fabricated, welded and machined. No after-treatment is needed to develop maximum corrosion resistance.

For all refinery tubing applications that demand exceptional corrosion resistance *plus* strength and toughness, remember Monel. And remember, too, that you can get Monel heat exchanger tubing right away. *No waiting!* Write, wire or phone your nearest Distributor—today!

*Reg. U. S. Pat. Off.

EMBLEM OF SERVICE
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THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

Find out Why so many pressure vessels are made of B&W CROLOY-CLAD PLATE

BABCOCK & WILCOX

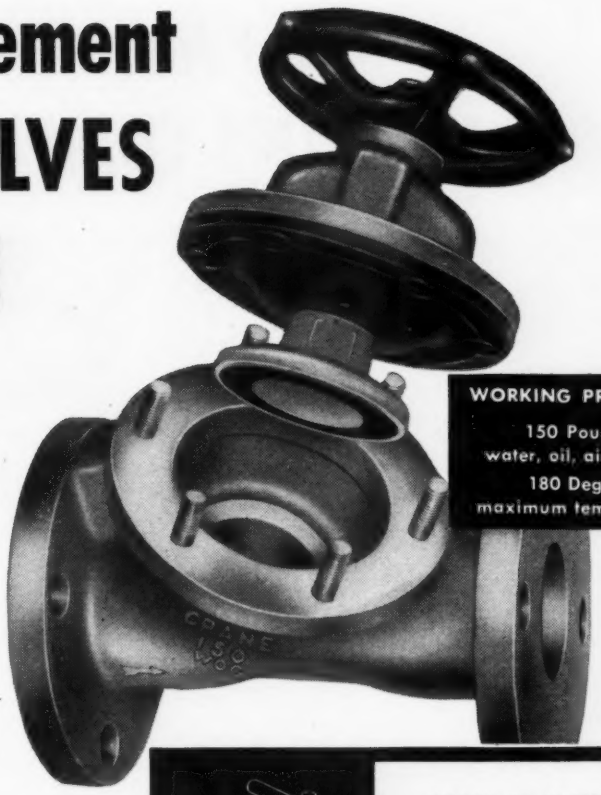
B&W Croloy-Clad Plate has gained wide acceptance as a cost-reducing, corrosion-resistant clad material for refinery and chemical pressure vessels.

Bulletin S-14 tells you all the facts, gives you the technical data, and shows you some typical installations of B&W-fabricated vessels. If you need pressure vessels with corrosion-, heat-, and oxidation-resistant surfaces, write today for Bulletin S-14. The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.

S-88

outstanding improvement in DIAPHRAGM VALVES by CRANE

NEW SEATING ARRANGEMENT MORE DURABLE... SAFER... MORE EFFICIENT



WORKING PRESSURE:
150 Pounds
water, oil, air or gas
180 Deg. F.
maximum temperature

Now, after completing exhaustive tests, Crane presents this better diaphragm valve—better suited for more services under today's working conditions. Stemming from basic improvements, such as the radically new bonnet-sealing and valve-seating arrangement, this original Crane design introduces many outstanding service features like those shown here.

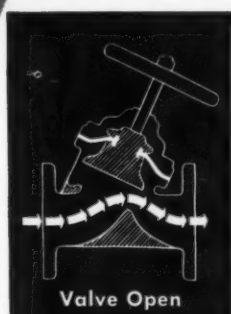
1. LONGER DIAPHRAGM LIFE, because diaphragm is used *only* to seal the bonnet—not for seating purposes.

2. POSITIVE SHUT-OFF in case of diaphragm failure. This is an exclusive Crane safety feature.

3. ACCURATE SEATING—new flat face disc with durable, resilient seating surface assures tight closure on all fluids.

4. GREATER FLOW CAPACITY with reduced resistance and pressure drop, assured by Crane Y-pattern body design.

5. EASIER OPERATION—Crane separate disc and diaphragm construction takes less torque—fewer turns—to operate.



HOW IT WORKS

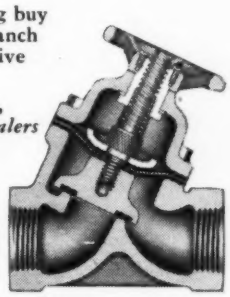
The Crane diaphragm serves one function only—sealing the bonnet. It is not subject to crushing and rapid wear. The seating member is a separate circular flat face disc, firmly attached to the stem and joined to the diaphragm with a special leakproof connection. This independent seating feature permits positive shut-off with no loss of fluid, even in case of diaphragm failure.

GET *THIS DESCRIPTIVE CATALOG*

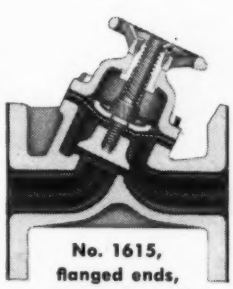
See these new valves—the outstanding buy in their class—at your local Crane Branch or Wholesaler. Or write for descriptive catalog AD-1761.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*

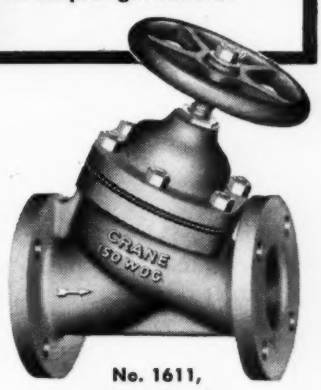
This new Crane line includes iron valves with screwed ends in sizes ½ to 2 in.; with flanged ends from ½ to 4 in. Neoprene coated valves —flanged ends only—in sizes from ½ to 4 in.



No. 1610, screwed ends



No. 1615, flanged ends, neoprene coated



No. 1611, flanged ends

EVERYTHING FROM . . .

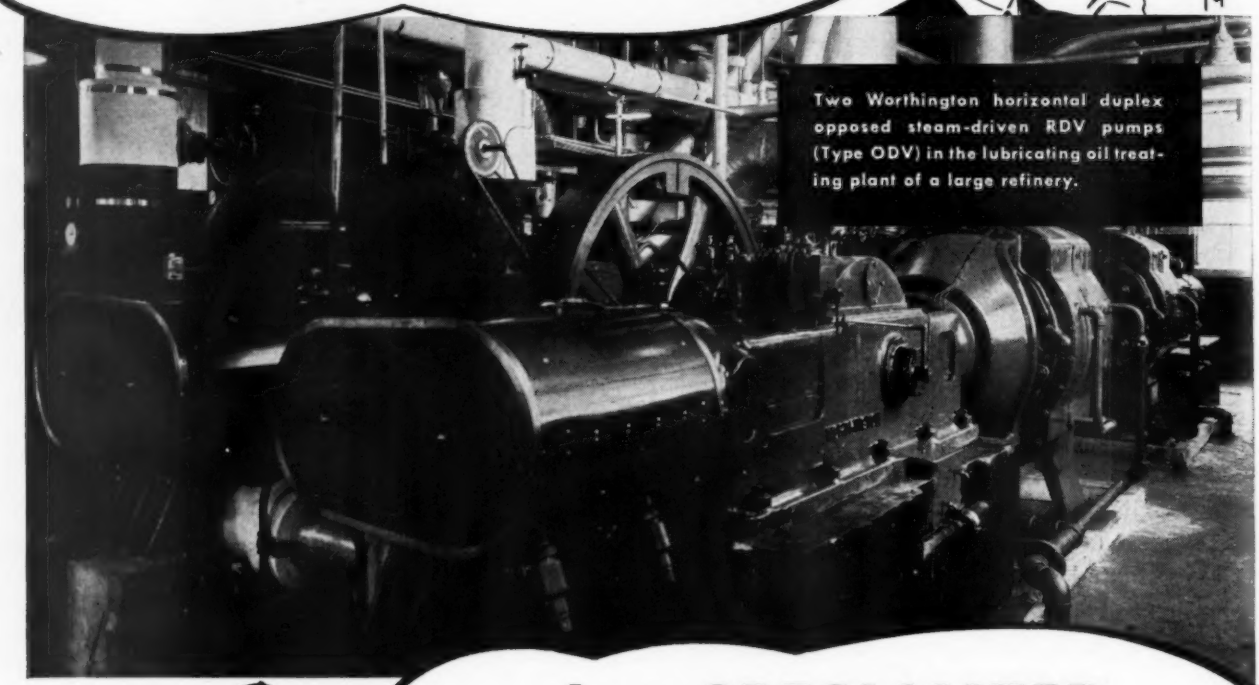
VALVES
FITTINGS
PIPE

CRANE

PLUMBING AND HEATING

FOR EVERY PIPING SYSTEM

Not Just "LOW-PRESSURE COMPRESSORS"



Two Worthington horizontal duplex opposed steam-driven RDV pumps (Type ODV) in the lubricating oil treating plant of a large refinery.

. . . but SPECIALIZED VACUUM PUMPS

Modern refinery practice demands the utmost efficiency in processing. And this efficiency can only be obtained with equipment that's *specifically designed for the job!* That's why, in refineries all over the world, WORTHINGTON is the top name in vacuum pumps.

These close clearance, high vacuum units are built with precision . . . Feather* Valves with hardened alloy seats and guards are the most efficient "breathers" made . . . extreme simplicity of construction gives unusual accessibility . . . top-grade materials insure greater ruggedness . . . conservative ratings give you abundant reserve power. No wonder, then, that in modern solvent extraction and solvent dewaxing plants WORTHINGTON vacuum pumps are the industry's first choice.

GET ALL THE FACTS

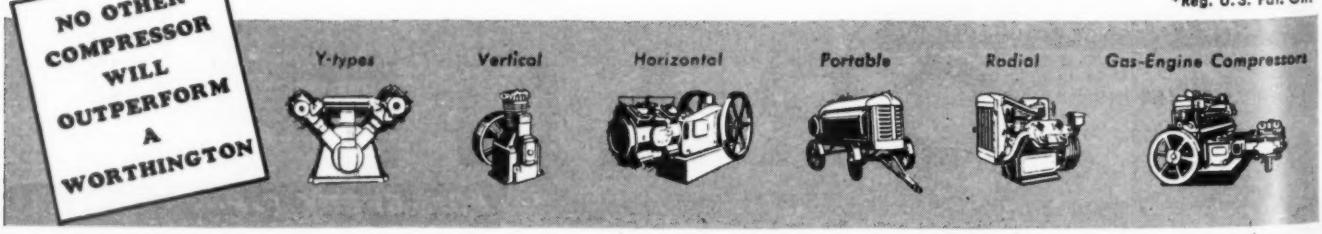
Worthington Horizontal Dry Vacuum Pumps are available in a variety of designs and drives permitting selection of the *right* unit to maintain the required vacuum at lowest operating cost. Bulletin L-710-B1B contains further facts proving *there's more worth in Worthington.* Write to *Worthington Pump and Machinery Corporation, Compressor Division, Buffalo, N. Y.*

WORTHINGTON

K.8.9

*Reg. U. S. Pat. Off.

NO OTHER COMPRESSOR WILL OUTPERFORM A WORTHINGTON



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for Petroleum and Chemical Processes

If you are a prospective purchaser of any such units, you will profit by consulting with Sun Ship. Here you have the benefit of long experience, exceptional skills and unlimited facilities. These facilities include our favorable location, because of which we can ship by water all units too large to be transported by rail... Also, the Sun reputation for building, reconditioning or repairing tankers and cargo vessels warrants your consideration when planning the overhauling or expansion of seagoing transport equipment.

Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY

When the Oklahoma Territory was opened at 12 noon on April 22, 1889, more than 20,000 people were lined up on the border. At a signal by U.S. Cavalry, a remarkable race for homesteads ensued.

ALWAYS NEW FRONTIERS *for* POWELL

The amazing development of the United States has been a result of continually opening new frontiers—not only geographical, but scientific and industrial as well. In the latter sphere, The Wm. Powell Company has a long and proud record of settling the flow control requirements of each new industrial frontier as it has appeared—including such achievements as inventing the first regrinding globe valve, pioneering in the field of corrosion resistance, meeting the need for specially designed valves for special services, and many others.

As a result of this continual pioneering, *only* Powell makes such a complete line* that no matter what your flow control requirements may be, Powell has the valves to meet them. Moreover, Powell Engineers are always ready to help you solve any problems that might arise.

Fig. 1793 — Large 125-pound Iron Body Bronze Mounted Gate Valve with outside screw rising stem, bolted flanged yoke, tapered solid wedge.

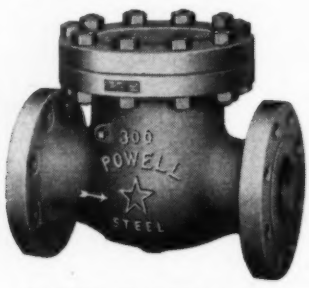


Fig. 3061—Class 300-pound Cast Steel Swing Check Valve. Flanged ends and bolted flanged cap.

Fig. 102—200-pound Bronze Globe Valve with screwed ends, union bonnet and regrindable, renewable wear-resisting "Powellium" nickel-bronze seat and disc.

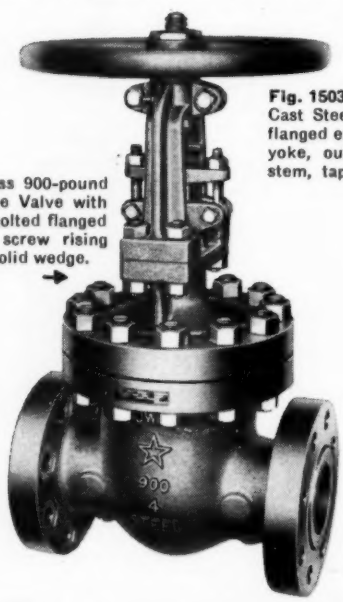


Fig. 9003—Class 900-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem, tapered solid wedge.

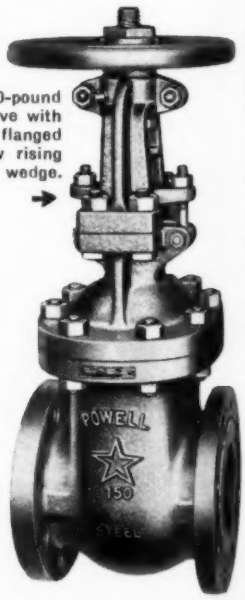


Fig. 1503—Class 150-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem, tapered solid wedge.

* **Powell Valves are made in Bronze, Iron, Steel and a wide selection of Corrosion-Resistant metals and alloys. Valves of every type—Globe, Angle, Gate, Check, Non-return and Flush Bottom Tank Valves—are included in the Complete Powell Line.**

The Wm. Powell Company, Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES

WARREN PETROLEUM CORPORATION DRIES BOTH LIQUID AND GAS WITH ALCOA ACTIVATED ALUMINA

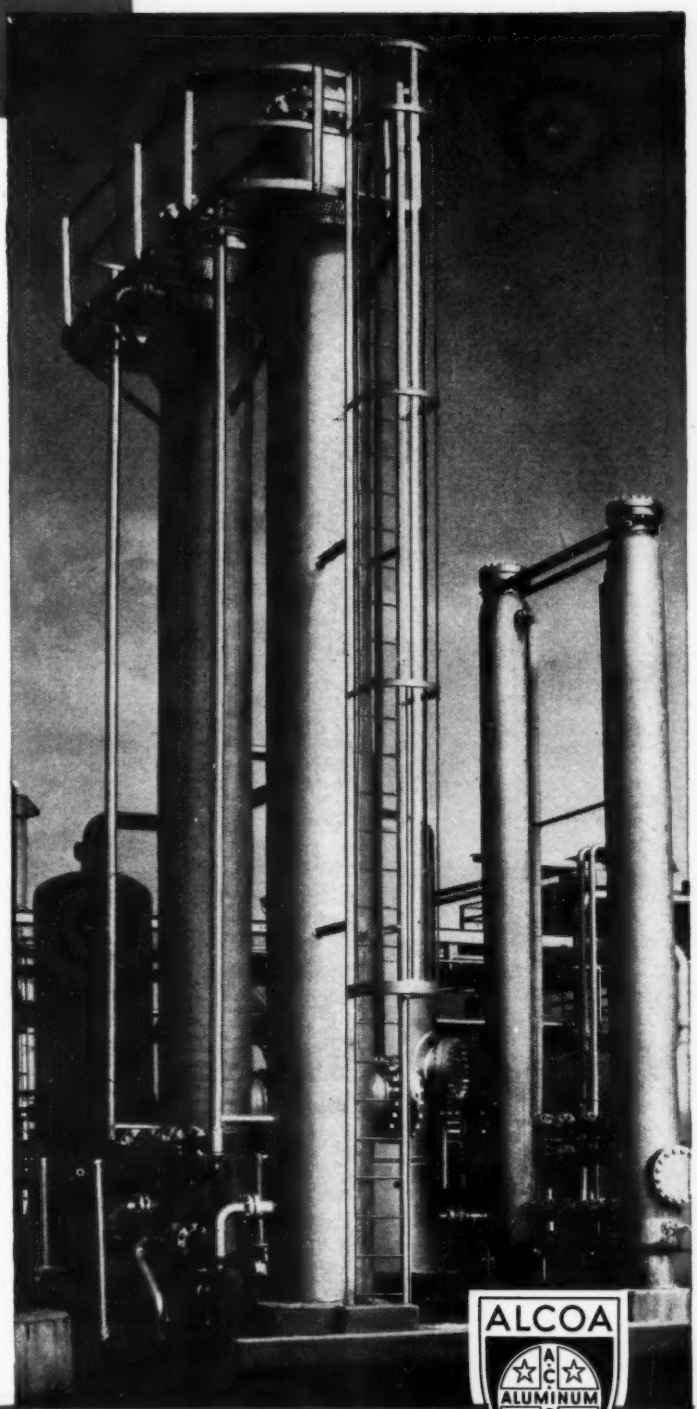
Because ALCOA Activated Alumina is economical for dehydrating both liquids and gases, Warren Petroleum Corporation uses it to dry liquid propane and residue gas to *minus* 40° F. dew point, at their Holliday, Texas, plant.

The larger pair of towers in the photograph are the residue gas dehydrators through which approximately 13 million standard cubic feet of gas is passed per day at a working pressure of 800 psig. Gas enters the towers at 80° F. to 90° F. Regeneration is accomplished in 4 hours with natural gas heated to 380° F., after which the tower is cooled before being put on stream.

The smaller pair of towers dehydrate 35,000 gallons of liquid propane per day at a working pressure of 215 psig. The liquid enters the towers at 80° F. to 90° F. Natural gas, heated to 380° F., is used for regeneration.

This is a typical example of ALCOA Activated Alumina "at work"—a desiccant that dries *both* liquids and gases quickly and efficiently. It also adsorbs certain gases and vapors from gaseous mixtures. Let us tell you more about this versatile drying agent. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 1780 Gulf Building, Pittsburgh 19, Pennsylvania.

Dehydrating units at Warren Petroleum Corporation, Holliday, Texas. Towers at left dry residue gas. Those at right dry liquid propane. All four towers charged with Alcoa Activated Alumina.



ALCOA CHEMICALS

ALUMINAS AND FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • LOW SODA ALUMINAS • TABULAR ALUMINAS • HYDRATED ALUMINAS

ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE

IN CATALYTIC REFINING

crudes vary . . . markets change

FILTROL* CATALYSTS GIVE REFINING BALANCE

More refiners use Filtrol catalysts each year because Filtrol catalysts have proven over the years to be more flexible–to produce quality with minimum refining costs from a wide selection of charging stocks.

Experienced refiners compare catalysts at their practical optimum, those plant operating levels which integrate with overall refinery balances. Refinery executives, production managers and technical staffs responsible for economical refinery balance –the men actually refining the bulk of America's production–the men who must take varying crudes and produce market demands–are using more Filtrol catalysts than ever before–proof that Filtrol catalysts give greater refining balance.

FILTROL CORPORATION

General Offices: 634 South Spring Street, Los Angeles, California
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CATALYSTS AND ADSORBENTS

RESEARCH AND DEVELOPMENT

*Reg. U. S. Pat. Off.

Now! Faster PROBOLOG checks heat exchanger tubes

New simple probe insertion with compressed air makes the use of Probolog a one man job . . . greatly speeds up tube checks.

Improved– HIGHER PROBE SPEED

Improved– MULTI-PURPOSE PROBES

Improved– SIMPLE, PRECISE CONTROL SETTINGS

Probolog is the much-discussed electronic instrument which makes visible, permanent records of the condition of individual, nonmagnetic tubes in heat exchangers and other tubular equipment.

After several years of commercial service, Probolog has earned a unique record of reduced maintenance costs, of unfailing accuracy and safety in the inspection of tubular equipment.

Shell has now added several improvements to the original Probolog, making it even more precise, more versatile and easier to use.

A new booklet contains a comprehensive description of Probolog and its operation. Please use the coupon. Demonstration can be arranged.

Shell Development Company, Incorporated
50 West 50th Street, New York 20, New York

Please send me a copy of "The Probolog."

Name_____ Title_____

Company_____

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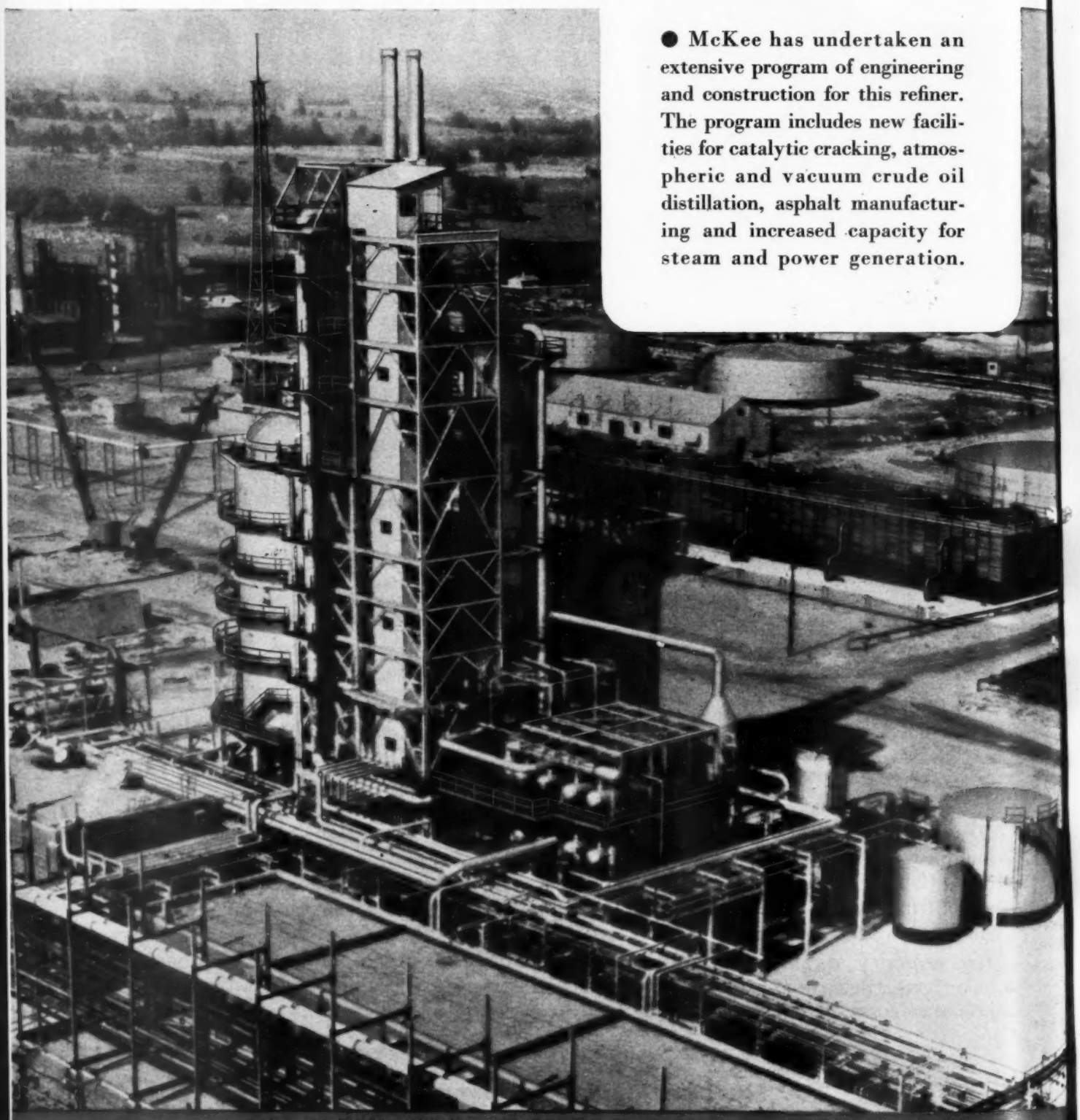
SHELL

NEW CATALYTIC CRACKING UNI

Engineered and Constructed by McKEE



● McKee has undertaken an extensive program of engineering and construction for this refiner. The program includes new facilities for catalytic cracking, atmospheric and vacuum crude oil distillation, asphalt manufacturing and increased capacity for steam and power generation.

ARTHUR G. McKEE & COMPANY

DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

ENGINEERS AND CONTRACTORS • ESTABLISHED 1905
2300 CHESTER AVENUE, CLEVELAND
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PETROLEUM PROCESSING
JULY, 1949

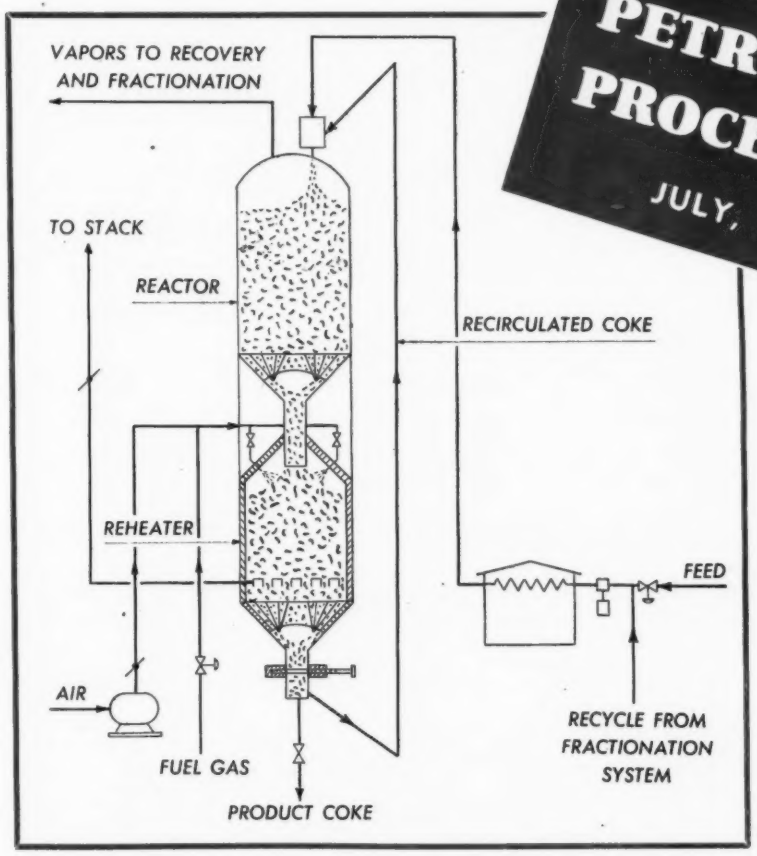

Fig. 1—Simplified flow diagram of the newly developed continuous contact coking process

New Process For

CONTINUOUS CONTACT COKING

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A new method for the conversion to coke and light oils of heavy-residuum oils and tars uses the principle of the continuous circulation of a stream of hot coke, produced in the process, contacted with a preheated oil charge. The coking reaction of the coke on the coke particles in the stream takes place during the gravity movement of the mass through a cylindrical reactor. Successive increments of coke build up the particles, and those of the desired size are drawn off as dry lump coke.

The product coke is of low volatile content and high mechanical strength. Vapors from the coking reaction produce gas and gasoline overhead, gas oil of a wide boiling range and bottoms, which can be recycled. The circulating coke stream is raised to the reactor in the standard, pressure-type round case elevators of the type used in TCC units. Heavier stocks may be processed than in conventional coking, it is claimed, with larger yields of light oils.

IN GENERAL, DURING the past 10 to 20 years, refiners have coked their heavy residual stocks to produce more valuable light oils when minimum fuel oil and maximum gasoline were desired. These coking operations were carried out in fired batch coke stills or with tubular oil heaters discharging into coking drums which were operated on a non-continuous or time-cycle basis. These processes have high labor requirements and require expensive coke-removal equipment.

During the war, and shortly after, residual fuels were in demand, thereby reducing the desirability of coking in the plant and deferring the stimulus for the development of new processes which would not have the disadvantages of shell stills or delayed coking. However, this situation has changed recently, owing to the requirement of maximum distillate oils for catalytic cracking charge and the shortage of light distillate oil required to cut the virgin residuum to fuel oil viscosity specifications. In addition, there is a reduced market for the final blended residual fuels, and the sales price has dropped considerably.

The conversion to coke and light oils of the heavy residual bottoms fraction of the crude, after all gasoline, kerosine, furnace oil and catalytic charging stock have been removed, results in additional catalytic charging stock, more gasoline, and releases to light heating oils the catalytic cutter oils otherwise used to blend off the flux tar bottoms to fuel specifications. Since the demand has increased for light oils to be used as heating and diesel fuels, any process which reduces the supply of residual fuel and increases the supply of light oils is very attractive from an economic standpoint. A new continuous and simplified coking process has

been developed for the conversion of these heavy-residuum oils and tars into coke and valuable light hydrocarbon products.

Summary

A simplified flow diagram of the recently developed continuous contact coking process is shown in Fig. 1. The heavy hydrocarbon residuum charge is preheated at a temperature of 750-850° F. in a conventional tubular preheater. Even the heaviest residual stocks have a viscosity of less than that of water at these temperatures. The preheated oil charge is then contacted on a relatively large quantity of hot circulating coke which has been produced in the process and is in the form of rounded lumps of ¼-in. to ¾-in. size. The temperature of the wetted coke after application of charge oil may be varied from 850 to over 1000° F. by changing the preheat or the circulation rate of the coke. The preheated residual hydrocarbon oils are distributed uniformly on the circulation coke.

Since the oil is practically non-viscous at these elevated temperatures, it distributes itself and is taken up by the coke particles as a thin liquid microfilm with no adhesion or agglomeration of the circulating solids occurring. No trouble arises from plugging or flow stoppage during the time the high-temperature, non-viscous residual oil is being coked to a solid. The coking reaction of the oil on the coke is carried on gradually in a cylindrical reactor vessel through which the wetted coke flows uniformly by gravity as a bed of free particles. The reactor volume is sufficient to give a solids residence time of 15 to 40 minutes, which is more than adequate to complete the conversion of liquid hydrocarbon to product vapors and dry coke.

The coke stream from the bottom of the reactor, carrying the increment coating produced from the forementioned coking step, passes through a sealing zone into a reheater, where it is heated by radiation and convection to the proper temperature for recirculation to the oil feed contact point. The circulation of the reheated coke may be carried out by conventional mechanical elevators, such as have been used successfully in catalytic cracking plants, or by means of a vapor lift system.

The vapors from the reactor are normally removed at the top, adjacent to the coke inlet, and are quenched in the usual manner with a heavier recycle stream. The oil vapor contains a mixture of cracked components which are produced from coking the heavier fractions of the charge and heavy virgin oil vapors which have been distilled under conditions of low pressure and high temperature at the oil charge contact zone. The products from this method of coking have been subjected to a minimum of cracking and degradation and are suitable for subsequent catalytic or thermal cracking.

As the coking operation proceeds, and successive increments of coke are deposited on the circulating particles, there is an increase of coke inventory in the system and a general increase in particle size. The net production is then drawn off as a free-running stream of dry lump coke of about ¾-in. diameter.

Since the coke is deposited in the form of many thin layers (1/1000-in.), and since it is reheated after each passage through the reactor, the product coke has a very dense structure instead of the foamy texture which is characteristic of the ordinary petroleum coke. The higher coking temperatures and lack of large pores give a low volatile content and high mechanical strength to the coke.

The continuous contact coking process produces less gas, less gasoline, more gas oil of superior quality, and less coke than do conventional coking methods operating on the same charge stock. Heavier stocks such as asphalts, pitches, and reduced tars may be processed, whereas the conventional methods, such as delayed coking, are limited to lighter materials which can be heated to a temperature of 900-930° F. in fired heaters.

The investment cost of continuous contact coker is about 60 to 80% of that for the most modern conventional methods, and a significant cost saving is obtained by the elimination of the coke-removal equipment and crew.

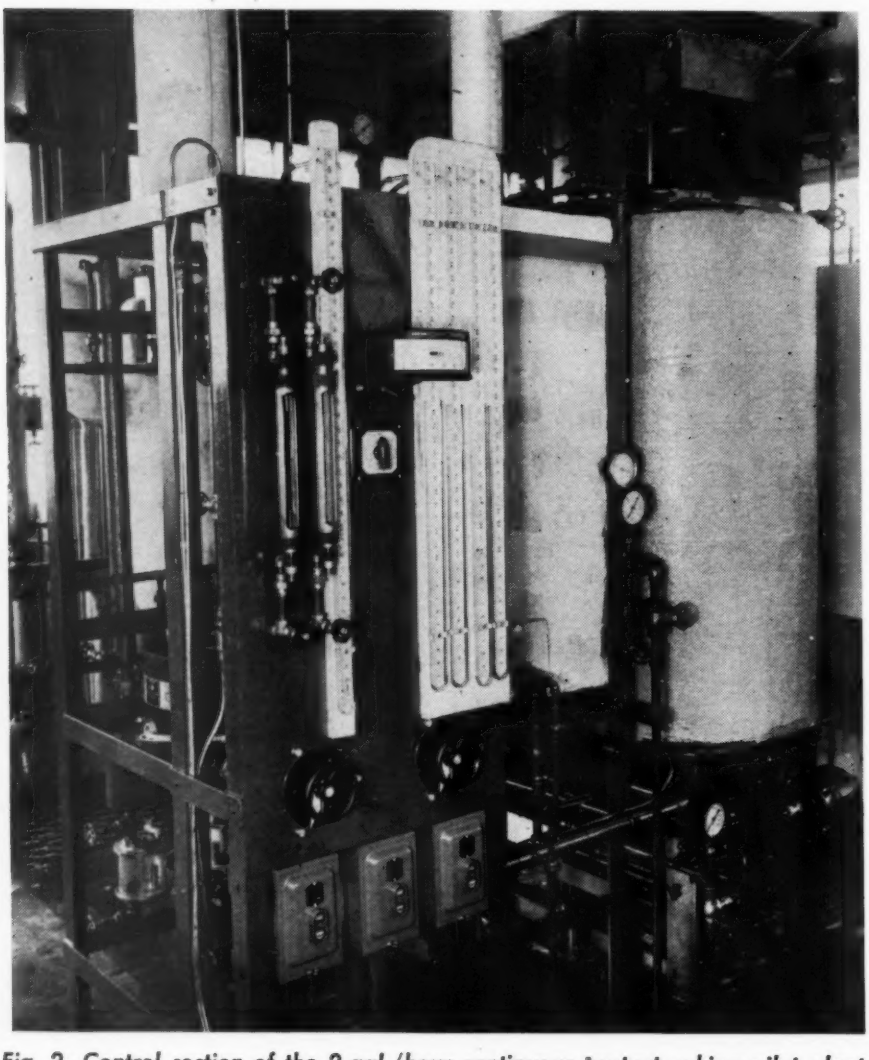


Fig. 2—Control section of the 2-gal./hour continuous contact coking pilot plant, constructed in the spring of 1944

Development of the Process

The development work on the continuous contact coking process began more than five years ago with the construction of an isothermal fixed-bed laboratory bench-scale unit. This unit was constructed to establish the range of process conditions required for the coking without binding together the solids with the coke product and to evaluate such basic vari-

ables as oil to solids ratio, solids residence time, and solids temperatures and their effect on yields of light hydrocarbon products and coke.

Operations on the fixed-bed unit demonstrated that the injected heavy oils would wet all of the particles approximately equally and that coking could be accomplished even in a static bed without cementing of the inert solids.

Charge stocks ranging from 4.8° A.P.I., 117° F. melting point Santa Maria bottoms to a light 18° API East Texas fuel oil were coked to obtain data for the design of a large-scale continuous laboratory pilot plant. Fig. 2 is a photograph of the control section of a 2-gal./hour continuous pilot unit which was constructed in the spring of 1944 and successfully operated on a variety of charge stocks and inert solids, including beach gravel, coke, and spent TCC catalyst. The operations using solids other than coke were made by continuously burning the deposited carbon from the circulating solids.

In the coking-on-coke runs the reheating of the circulating coke was done by continuous partial combustion. Only the necessary quantity of coke was burned to reheat the circulating coke mass to the desired contact temperature. Coking-on-coke runs were also made by continuous non-oxidizing reheating using radiation and convection. Most of the latter runs were made for coke production, since the fuel balance in most refineries is such that an operation for coking-on-coke with the production of coke as a product looked more generally attractive than an operation using inert refractory solids with generation of steam from the heat of combustion of the residual coke. Extended runs were also made to determine the characteristics of the equilibrium coke after 65 passes through the coking reactor.

The early pilot unit data were checked and extended by independent pilot plant work in the Gulf laboratories.

The combined laboratory-scale pilot plant work described above had defined the solids to oil ratios, solids residence time, temperature, and yield distribution characteristics of the contact coking process. It had also shown the feasibility of using coke as a circulating material and producing coke continuously as a product.

Since most of the current interest in the process was for the production of catalytic charge stock having as near virgin characteristics as possible, large samples of the gas oil product were needed for evaluation of its catalytic cracking characteristics. For this purpose an existing pilot unit was converted to a 50 b/d continuous coking pilot unit.

The operation of this semi-commercial pilot unit (Fig. 3) in the summer of 1947, in addition to producing large samples of products, was valuable as a means for evaluating alternative methods for charge oil application, coke reheating, and coke flow-controlling devices. There were inherent limitations (inadequate bed depth) in the converted equipment, which necessitated operations being made at temperatures higher than desirable, but the yields and product distribution bore out the results obtained on the smaller pilot plants. Complete evaluations, including catalytic cracking of the products, were obtained in extensive pilot plant investigations on the synthetic crudes produced in the 50 b/d pilot unit.

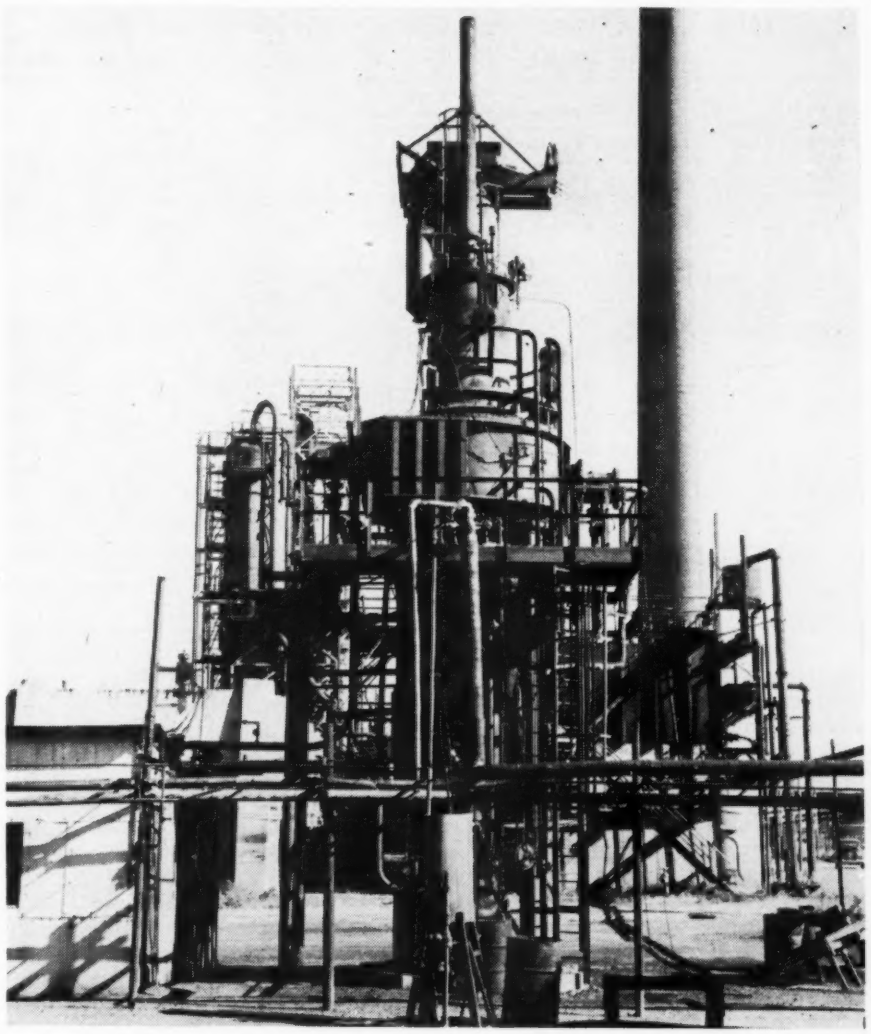


Fig. 3—Semi-commercial 50-b/d continuous coking unit put into operation in 1947

Product Quality and Yields

The data from several representative contact coking runs are given in Table 1, together with the characteristics of the gas oils produced. These coker gas oils are of near virgin character, as reflected by the characterization factors; they show only a very slight decrease from the characterization factors of the virgin charge stocks. The lighter products show increasing degrees of unsaturation as the molecular weights decrease. Thus, the gases are highly unsaturated, and the gasolines usually run eight to ten octane numbers higher than those from conventional coking and have eight to fourteen points spread between Research and Motor octane numbers, depending upon the reactor temperature employed.

The results obtained by once-through contact coking of a 30% Eastern Venezuela reduced crude on inactive clay and coke are given in Table 2. A high yield of gas oil was obtained, of near virgin character and boiling range suitable for catalytic cracking charge. Correlations of data obtained over a wide range of operating conditions show that the conversion per pass to 900° F. endpoint gas oil increases as the average reactor temperature is decreased, provided the reactor volume is sufficient to permit complete coking of the unvaporized oil. The production of dry gas at a given conversion increases rapidly with reactor temperature. The yield of gasoline and the gaso-

TABLE 1—Pilot Plant Contact Coking of Various Reduced Crudes

Reduced Crude Charge	42% West Texas	15% West Texas	Illinois			Santa Maria	Eastern Venezuela
Pilot Plant	Laboratory	Semi-Commercial	Semi-Commercial	Lab.		Lab.	Lab.
Type of Operation			Single-Pass				
Product Yields, % of reduced crude charge							
Gas (C_3 & Lighter), wt.%	3.1	4.0	13.0[1]	8.1[1]	2.9	7.1	5.3
Gasoline, vol.%	4.8	4.9	15.7	12.1	13.7	8.0	7.6
Gas Oil, vol.%	83.1	84.8	70.9	80.3	83.8	65.0	81.6
Coke, wt.%	6.8	6.5	5.1	3.1	8.1	15.4	13.6
Loss, wt.%	2.7	0.0	1.1	0.4		1.2	0.0
Reduced Crude Inspections							
Gravity, °A.P.I.	18.2		10.7	18.4		5.8	13.4
Viscosity, S.U.S. at 210° F.	97.4			169			
Vol.% Overhead at 900° F.	53		15	33		23	25
Carbon Residue, %	6.4		11.5	8.0		14.2	13.8
Characterization Factor	11.7		11.25	11.8		11.4	
Gas Oil Inspections							
Gravity, °A.P.I.	23.2	23.5	17.5[2]	22.9[2]	25.8	17.0	20.9
Viscosity, S.U.S. at 210° F.	41.7	40.6		48.0			56.2
Characterization Factor	11.6	11.6	11.31	11.8	11.75	11.2	
Vacuum Distillation, °F. at 760 mm.							
10%	550	528	600	634	530	405	606
50%	752	745	807	841	760	755	815
90%	977	977	939	974	935	955	984
Endpoint	1003	1003			1000	965	

[1] Yields from the semi-commercial pilot plant are not representative of optimum operating conditions due to limited reactor volume.

[2] Inspections are of rerun gas oils with yields of 43.4 and 57.5 vol.% of charge from West Texas and Illinois reduced crudes, respectively.

line octane number increase with an increase in vapor outlet temperature and are nearly independent of the type of solids used.

Data from once-through Thermofor catalytic cracking of contact coker gas oil from Eastern Venezuela reduced crude are shown in Table 3. The yield of catalytic cracking charge was 71% of the original charge to the once-through contact coker, and the overall yields from the combined coking and cracking are shown in Table 4. It will be noted that this processing produced 30 vol. % of debutanized 74 Motor octane gasoline and a propane-free liquid recovery of 87 vol. %.

Catalytic cracking data obtained by Fluid cracking of the rerun gas oil from the 50-b/d contact coker runs on Illinois reduced crude are given in Table 5. This gas oil produced higher gasoline octane numbers and somewhat higher yields of coke and gas at the same conversion than did a virgin gas oil from the same crude. Allowance in evaluating the data sould be made because this coker gas oil was produced under unusually severe conditions imposed by the limited reactor volume in the 50 b/d unit. Unusually high carbon residues were obtained in rerunning this coker synthetic crude after storage for several months. The carbon

TABLE 3 — Single-Pass Thermofor Catalytic Cracking of Contact Coker Gas Oil from Eastern Venezuela Reduced Crude

Cracking Conditions	
Catalyst	31 Activity Natural
Average Reactor Temperature, ° F.	943
Space Velocity, V/hr./V	1.59
Catalyst to Oil Ratio, tons/hr./1000 bbls. oil/day	11.3
Coke Burnoff, lbs./hr./1000 bbls. oil/day	520
Type of Operation	Concurrent-Adiabatic
Product Yields, vol. % of gas oil charge	
Debutanized Gasoline	29.1
Butane-Butene	6.7
Propane-Propylene	5.6
Furnace Oil	27.2
Heavy Gas Oil	33.1
C_2 & Lighter (wt. %)	3.8
Coke (wt. %)	3.9
Cracking Stock Inspections	
Gravity, °A.P.I.	22.8
Bromine Number	21
Aniline Point, ° F.	167
Carbon Residue, %	0.03
Characterization Factor	11.7
Vacuum Distillation, ° F. at 760 mm.	
10%	579
50%	825
90%	950
Product Inspections	
Gasoline	
Gravity, ° A.P.I.	53.5
Reid Vapor Pressure, lbs./sq. in.	5.4
Aniline Point, ° F.	63
Bromine Number	88
Preformed Gum, mg./100 cc.	144
Copper Dish Gum, mg./100 cc.	462
Oxygen Stability, minutes	74
Sulfur, %	0.38
A.S.T.M. Distillation, ° F.	
I.B.P.	110
10%	140
50%	266
90%	383
E.P.	420
Motor Octane Number, clear.	78.6
, +3 cc. T.E.L.	82.7
Research Octane Number, clear.	90.0
, +3 cc. T.E.L.	95.0
Total Gas Oil	
Gravity, ° A.P.I.	20.1
Aniline Point, ° F.	127
Bromine Number	14
Viscosity, S.U.S. at 100° F.	46
Carbon Residue, %	0.91
Sulfur, %	1.15
Vacuum Distillation, °F. at 760 mm.	
10%	477
50%	640
90%	795

TABLE 2—Once-Through Contact Coking of 30% Eastern Venezuela Reduced Crude

Run Number	53	54	55A	55B
Solid Medium	— 7 A.I. Clay —		— Coke —	
Operating Conditions				
Oil Inlet Temperature, ° F.	851	852	848	847
Oil Vapor Outlet Temperature, ° F.	898	873	862	832
Solids Inlet Temperature, ° F.	953	955	902	857
Average Reactor Temperature, ° F.	845	838	855	840
Reactor Pressure, lbs./sq. in. gage	7.0	5.1	5.0	5.0
Solids Residence Time, minutes	30	29	20	20
Yields, vol. % of charge				
Debutanized Gasoline	9.1	9.4	5.3	5.9
Butane-Butene	1.6	1.6	2.3	2.3
Propane-Propylene	1.9	1.9	2.9	2.8
Furnace Oil	6.8	6.3	5.9	3.5
Heavy Gas Oil	71.0	72.5	75.7	72.3
Gas (C_2 & Lighter), wt. %	1.7	1.6	2.4	2.5
Coke, Wt. %	15.6	14.7	13.6	18.8
Charge Stock				
Gravity, ° A.P.I.	13.2	Same	Same	Same
Carbon Residue, %	10.9	as	as	as
Sulfur, %	1.67	Run	Run	Run
Vacuum Distillation, °F. at 760 mm.		53	53	53
Overpoint	502			
10%	760			
20%	825			
30%	878			
40%	950			
Properties of Rerun Products				
Gasoline				
Gravity, ° A.P.I.	51.0	49.6	53.3	54.9
Reid Vapor Pressure, lbs./sq. in.	1.4	1.0	1.0	3.0
Oxygen Stability, minutes	456	14		
Preformed Gum, mg./100 cc.	18	168	57	
Bromine Number	91	75	84	
Aniline Point, ° F.	93	94	128	128
Sulfur, %	0.6	1.4	0.6	0.6

[1] 90% overhead on Run 54 total gas oil was 22.8° A.P.I., 0.03 carbon residue. See Table III.

Run Number	53	54	55A	55B
Solid Medium	— 7 A.I. Clay —		— Coke —	
A.S.T.M. Distillation, ° F.				
I.B.P.	176	164	160	143
10%	228	218	219	201
50%	300	300	299	280
90%	375	374	360	365
E.P.	409	403	398	392
Motor Octane Number, clear.	67.6	63.9	60.2	60.4
+3 cc. T.E.L.	74.1			
Research Octane Number, clear.		71.2		
Furnace Oil				
Gravity, ° A.P.I.	32.9	32.4	33.4	35.3
Aniline Point, ° F.	113	120	128	131
Sulfur, %	1.2	1.3	1.3	1.2
A.S.T.M. Distillation, °F.				
I.B.P.	416	440	448	428
10%	445	465	470	450
50%	483	506	501	482
90%	559	580	569	554
E.P.	609	620	629	602
Total Gas Oil				
Gravity, ° A.P.I.	21.8	21.8	20.9	22.2
Acid Heat, ° F. (A.S.T.M.)	35	41	21	30
Aniline Point, ° F.	170	178	173	175
Bromine Number	19	21	13	17
Pour Point, ° F.	95	95	105	105
Sulfur, %	1.3	1.3	1.2	1.4
Carbon Residue, %	0.9	1.3[1]	1.9	0.9
Viscosity, S.U.S. at 130° F.	95.5	142	189	146
, S.U.S. at 210° F.		50.5	56.2	51.0
Vacuum Distillation, °F. at 760 mm.				
I.B.P.	399	440	391	409
10%	537	578	606	572
50%	763	828	815	805
70%	815	872	886	862
90%	885	934	984	942

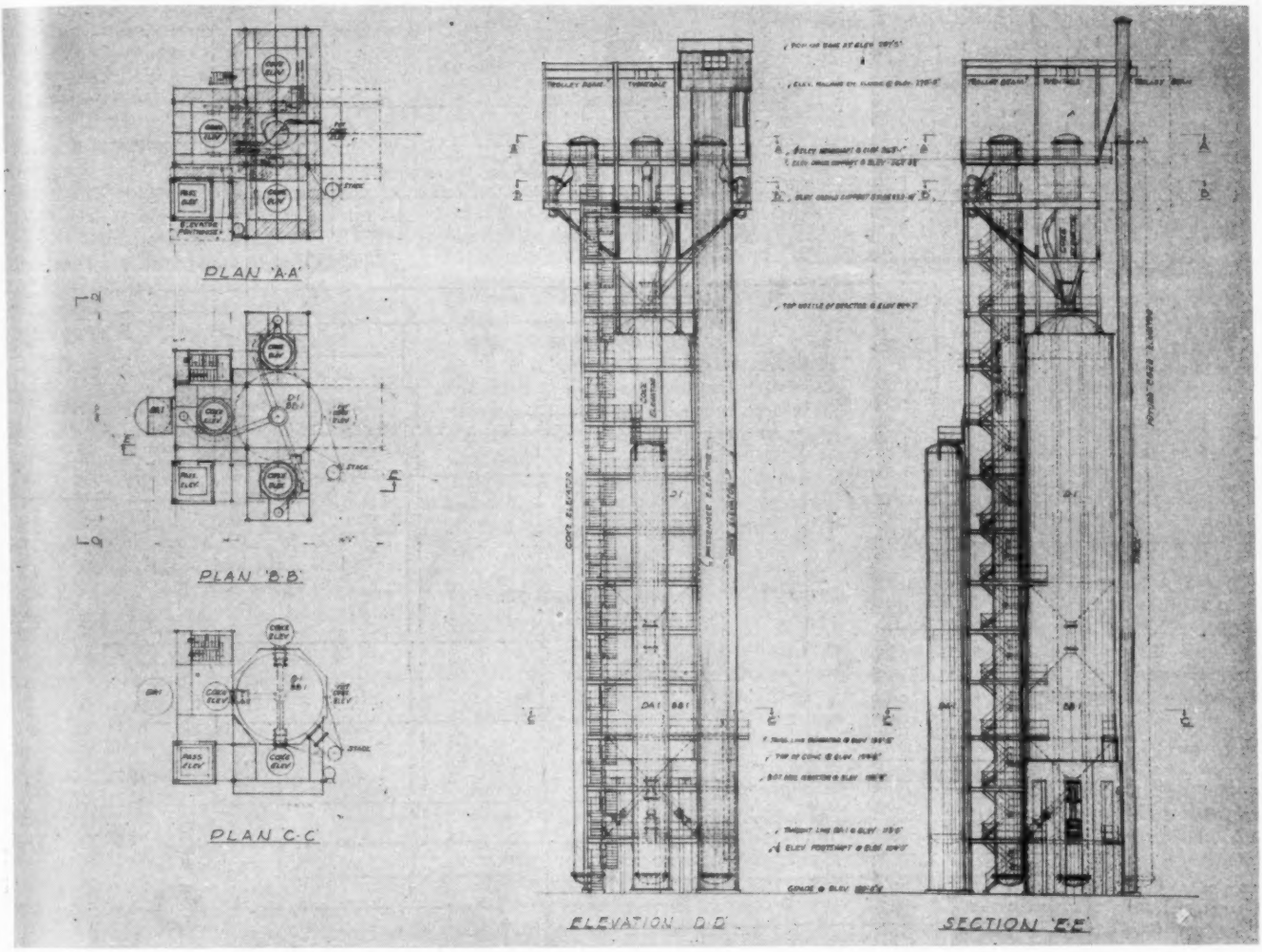


Fig. 4—General arrangement and structure of a commercial contact coking unit

yield on catalytic cracking is therefore higher than would be expected on a combined commercial operation.

The contact coking process produces a coke of ½-in. to over ¾-in. particle size, having 1.5 to 5.0% volatile matter, 0.5% ash, and a bulk density of 58 to 60 lbs. per cu. ft. The sulfur content will depend on that of the reduced crude charge. The coke is relatively low in porosity and very high in mechanical strength, individual particles having a crushing

TABLE 4—Contact Coking and Thermofor Catalytic Cracking of Eastern Venezuela Reduced Crude[1]

Yields, vol. % on charge to coking unit	
Debutanized Motor Gasoline	30.0
Butane-Butene	6.4
Propane-Propylene	5.9
Furnace Oil	19.3
Heavy Gas Oil	31.3
Gas (C_2 & Lighter), wt. %	4.1
Coke, wt. %	17.3[2]
Octane Number of Combined Gasoline, C_5 Free Motor, clear	74.0

[1] Combined yields from once-through continuous contact coking and Thermofor catalytic cracking of the 30 per cent reduced Eastern Venezuela crude.
[2] Carbon residue of reduced crude—13.5%.

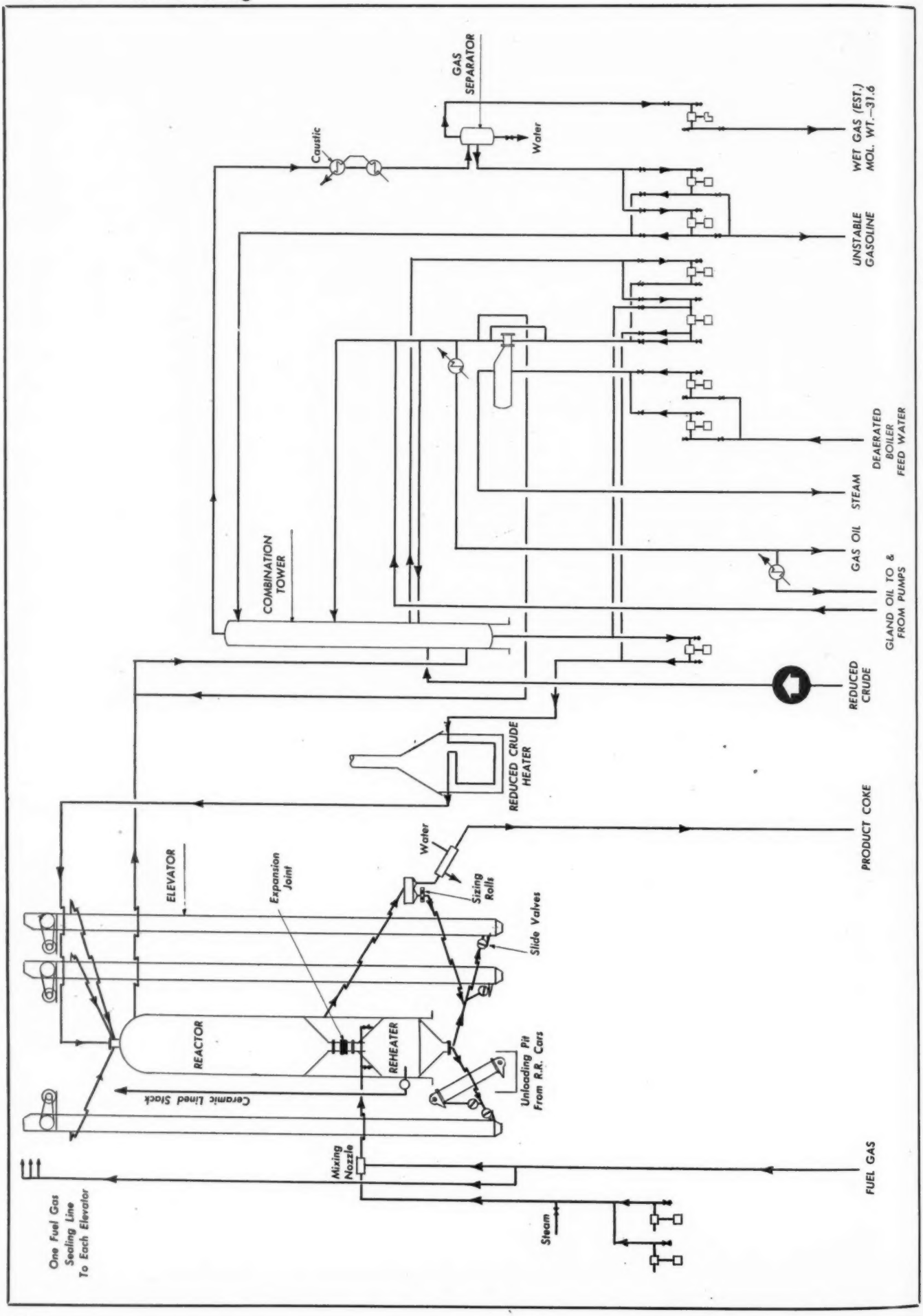
TABLE 5—Single-Pass Fluid Catalytic Cracking of Contact Coker Gas Oil from Illinois Reduced Crude

Run Conditions	
Catalyst	28 Activity Synthetic
Average Reactor Temperature, ° F.	926
Space Velocity, W/hr./W (Total Feed Basis)	3.33
Catalyst to Oil Ratio, W/W (Total Feed Basis)	9.0
Slurry Oil Recycle, vol. % of fresh feed	10
Estimated Commercial Carbon Burnoff, lbs./hr./1000 bbls. fresh feed/day	768
Yields, vol. % of gas oil charge	
10 R.V.P. Gasoline	46.5
Excess Butane-Butene	5.3
Propane-Propylene	6.2
Furnace Oil	19.9
Heavy Cycle Stock	21.1
Slurry Oil	5.0
C_2 & Lighter (wt. %)	2.5
Coke (wt. %)	5.8
Cracking Stock Inspections	
Gravity, ° A.P.I.	22.7
Bromine Number	18
Aniline Point, ° F.	180
Vacuum Distillation 95% Point at 760 mm.	989
Characterization Factor	11.78
Carbon Residue, %	0.73[1]

[1] Coker synthetic crude stored for several months before rerunning. On commercial tower, carbon residue would be 0.2% maximum (see Table III), thus catalytic cracking coke yields are higher than representative.
[2] Inhibited with 10 lbs. U.O.P. No. 5 per 1000 bbls.

Inspections of Rerun Products	
Gasoline[2]	
Gravity, ° A.P.I.	58.7
Reid Vapor Pressure, lbs./sq. in.	10.5
Bromine Number	118
Aniline Point, ° F.	64
Preformed Gum, mg./100 cc.	14
Copper Dish Gum, mg./100 cc.	347
Oxygen Stability, minutes	468
Sulfur, %	0.13
A.S.T.M. Distillation, ° F.	
I.B.P.	96
10%	119
50%	223
90%	375
E.P.	406
Octane Numbers (Corrected to 10 R.V.P.)	
Motor, clear	79.4
, +3 cc. T.E.L.	82.9
Research, clear	94.3
, +3 cc. T.E.L.	97.7
Furnace Oil	
Gravity, ° A.P.I.	22.3
Aniline Point, ° F.	72
Sulfur, %	0.83
A.S.T.M. Distillation, ° F.	
I.B.P.	414
10%	496
50%	529
90%	589
E.P.	629
Heavy Cycle Stock	
Gravity, ° A.P.I.	18.6
Aniline Point, ° F.	151
Sulfur, %	0.72
Viscosity, S.U.S. at 130° F.	59
Vacuum Distillation, °F. at 760 mm.	
10%	668
50%	728
90%	788

Continuous Contact Coking



strength of 600 lbs. per sq. in. The burning charatceristics of the coke as a fuel have been tested and found to be at least equal to anthracite coal, with the added advantage of low ash content. It is a premium fuel for either domestic or industrial use. For electrode manufacture the low volatile and moisture contents are advantages. Calcining to 0.5% volatile content can be done cheaply and with low loss by providing a calciner on the coking unit and by charging the hot product coke stream to utilize the waste heat in the process.

Commercial Plant Design

Complete designs and estimates have been made for contact coking units of 6,500 to 10,000 b/d reduced crude charging capacity. The general arrangement of the reactor and tower structure for a typical commercial unit is shown in Fig. 4. A flow diagram showing operating pressures, temperatures and flow rates is shown in Fig. 5. In this unit the reduced crude charge is preheated in a conventional fired heater to 850° F. and is then thoroughly contacted with the circulating stream of preheated coke particles. The oil-laden coke particles are then introduced into the top of the reactor and flow down through the reactor as a moving bed. The residence time for the solids in the reactor is 30 to 40 minutes, during which time the hydrocarbon liquid is converted into vapor and dry coke. The coke is deposited as a very thin layer on the original coke particles.

At the bottom of the reactor the coke flows through a specially designed solids drawoff device which maintains uniform flow in the reactor and passes through a vertical seal leg into the top of the coke reheater.

In the coke reheater, radiant combustion burners supply heat to the circulating coke, and convection heat is also obtained from the resulting flue gases.

From the bottom of the reheater the coke flows by gravity through control valves to the elevator charge inlets. Constant inventory is maintained as coke is produced by continuously drawing off a net coke product stream of the largest particles. The average particle size of the circulating coke is maintained by passing a portion of the circulation through adjustable sizing rolls.

The coke elevators for this unit are standard pressure-type round case elevators of the same type which have given very satisfactory service in TCC plants. The operating conditions in coking service are milder than in catalytic cracking, since no abrasive dust is present, and the solids temperatures are lower than those prevailing in cracking service.

The vapors from the coking reactor are quenched and fractionated in a conventional low-pressure tower to produce gas and gasoline overhead, 400 to 900° F. boiling-range gas oil, and bottoms. A 400 to 700° F. boiling-range gas oil may be produced, if desired. The bottoms are recycled to the coking reactor to obtain ultimate yields.

Fig. 5—Process flow diagram of a typical commercial unit

TABLE 6—Comparison of Contact and Delayed Coking Yields Recycling to Ultimate Yields

Operation	Contact Coking	Delayed Coking	Contact Coking	Delayed Coking
Reduced Crude Charge	—Mid-Continent—		—West Texas—	
Reduced Crude Inspections				
% on Crude	26.5	26.5		
Gravity, ° A.P.I.	20.6	20.6	14.3	14.3
Carbon Residue, %	8.2	8.2	11.5	11.5
Product Yields, % on Coker Charge				
Gas, wt. %	6.0	7.0	7.4	7.8
10 R.V.P. Gasoline, vol. %	14.9	21.6	16.9	23.9
Gas Oil, vol. %	75.5	66.5	70.9	59.3
Coke, wt. %	11.5	14.0	15.0	19.3
Gas Oil Endpoint, ° F. at 760 mm.	830	830	900	900

TABLE 7 — Utility Requirements—Contact and Delayed Coking

Basis: 19,000 barrels per operating day of 18° A.P.I. reduced crude available at 650° F., generating steam from waste heat on coking units.

	Contact Coking	Delayed Coking
Cooling Water, gpm	4,660	8,750
High-Pressure Steam, lbs./hr.	None	25,000
Electric Power, kw	210	90
Fuel, millions of btu/hr.	79	115
Labor, operating men/shift	4	10

Comparison of Contact and Delayed Coking

A comparison of yields obtainable by contact and delayed coking of two different reduced crudes is given in Table 6 for operations aimed at maximum production of gas oil for catalytic cracking charge. The contact coker shows 9 to 11% higher gas oil yields and lower gas, gasoline, and coke yields than the delayed coker, as would be expected from the lower heater temperatures and minimum vapor cracking characteristic on contact coking operations of this type.

The comparative utility requirements given in Table 7 reflect the elimination of the high-pressure decoking water pump in the contact process and the labor savings due to the elimination of the decoking crew.

In various cases where construction cost estimates have been prepared for contact coking and delayed coking, including complete fractionation equipment, the contact coker cost has amounted to a value of 60-80% of that for delayed coking. This savings depends on the size of the unit, the use of alloys, and various other factors, and is in general greater for the medium-capacity units, since the cost of the hydraulic decoking equipment used with delayed coking remains essentially constant, regardless of plant capacity. When the coking section alone is considered, as in cases where coking facilities are to be added to an existing heater and tower system, the savings may be even greater.

It will be seen from the compact plot layout for the contact coker that the space requirements are less than for conventional coking plants. The delayed coker requires more space for its decoking water recovery and settling system than the entire plot space for the contact coker.

The continuous contact coker has an unusual degree of flexibility. It can charge any heavy residual stocks that may be available, whereas vacuum bottoms and asphalts are not suitable charges for delayed coking, since they require heater outlet temperatures above 900° F. The contact coker is not limited by coking conditions in a fired coil heater, since the stream of circulating coke which largely controls the reactor bed temperatures may be maintained at a wide range of temperatures without changing the oil charge preheat. When operating for maximum yield of catalytic cracking charge gas oil the degree of thermal cracking may be minimized in the contact coker by changing the reaction temperature, but if a maximum yield of intermediate boiling-range gas oil is required, the vapor cracking time may be varied independently of the liquid soaking time. Such independent variation is not possible in delayed coking.

If minimum coke yields should be desired, the operation may be carried out at relatively high reactor temperature and low oil partial pressure to obtain a very low coke yield and a small yield of fuel oil.

Acknowledgment

The writers wish to acknowledge the contributions of the various laboratories for the work done in connection with the development of this process. The isothermal fixed-bed and continuous pilot plant coking runs were made at the Lummus Co. Laboratories. The 50 b/d pilot plant was operated by the Standard Oil Co. (Ohio) at their Lima Refinery. The pilot plant coking work on Venezuela stocks and the complete evaluation of the synthetic crudes from the Lima pilot unit were made by Gulf Research & Development Co. This included both Thermofor and Fluid cracking of the products.

Automatic Recorder For Catalyst Loss On Cracking Units

By J. H. RAMSER and J. W. HICKEY
Atlantic Refining Co., Philadelphia

An instrument which indicates and records continuously the quantity of catalyst being carried away with the flue gas from a Fluid catalytic cracking unit has been designed and put into use at one refinery. It consists of an optical device to measure catalyst concentration and a flowmeter to measure flue gas velocity, both coupled by a mechanism which gives readings in terms of instantaneous loss of catalyst per unit time, as well as accumulated total loss. The instrument provides operators with an immediate check on losses, as compared to the previously-used 2-hour spot test.

LOSS of catalyst escaping with the flue gas from a fluid type catalytic cracking unit may vary from a fraction of a ton to several tons per day, depending on operating conditions.

The high cost of catalyst would seem to indicate that complete recovery is desirable. However, for practical reasons, this is not feasible. An upper limit of catalyst concentration in the flue gas may be fixed through local smoke-abatement ordinances. Or, in the absence of such laws, the upper limit is fixed by the fact that a high selective loss of catalyst fines produces poor fluidization of the catalyst in the unit. Therefore, efficient operation of a cracking unit requires that the loss be known and controlled within such limits as the above-mentioned factors warrant.

The conventional 2-hour spot test for catalyst loss, wherein the flue gas is filtered through a porous thimble, is time-consuming. It also has the additional disadvantage that trends in loss are not readily discernible unless frequent and accurate spot tests are made. Further, it is of little use when the catalyst concentration fluctuates widely, such as during start-ups and other periods of unsteady operation.

It seemed therefore desirable to develop a completely automatic instrument, which records continuously the instantaneous as well as the accumulated loss of catalyst. The instrument described has been designed especially to meet the stringent conditions of stability, accuracy, continuous service and low maintenance which such a recorder should satisfy.

The device has been used on a commercial cracking unit with satisfactory results. In addition to recording loss, the instrument has been found helpful in correlating trends in loss with operating conditions. It also may be used for checking the operation of the Cottrell rappers, since each rapper produces its own peak on the recorder chart.

Principle of Operation

The loss recorder comprises three different functional parts: (1) means for measuring catalyst concentration in the flue gas, (2) means for measuring flow rate of flue gas, and (3) means for multiplying concentration into flow rate to obtain automatically the instantaneous loss per unit time.

The meter for catalyst concentration consists of a light source mounted on one side of the flue gas stack and a thermopile on the other side. Preliminary laboratory investigations and actual calibrations at the stack have shown that the relation between the votlage output, E, of the thermopile and the catalyst concentration, c, may be represented approximately by the equation

$$c = k\ (\log E_0 - \log E) \quad \ldots\ldots (1)$$

in which E_0 is the voltage output corresponding to zero concentration and k an empirical constant. The value of the constant depends mainly on the thickness of the light-dispersing medium: it was found to be little affected by variations in particle size and surface reflectivity, which are encountered under practical operating conditions.

For a stack diameter of 4 ft., k was found to be 190 if the concentration is expressed in lbs./million cu. ft. The value of E_0 depends on the intensity of the light source. To be within the range of the voltage recorder, it may be necessary to reduce E_0 and E by a common factor. This may be done by connecting a potentiometer across the thermopile. The voltage output of the potentiometer, which is E'_0 at zero concentration ($E'_0 < E_0$), is then fed into the voltage recorder.

The intensity of light entering the stack may vary slightly with time. This is partly due to variations in light output and partly due to variable losses of light between the source and the stack. Therefore, it may be necessary occasionally to reset the voltage which corresponds to zero concentration to the value chosen for E'_0. This may be done, during operation of the unit, by means of two tubes which are pushed into the stack from either side. These tubes completely enclose the light beam when they meet at the center of the stack. The flue gas with its suspended catalyst is displaced from the tubes

* Condensed slightly from an original paper by the same authors, "A Catalyst Loss Recorder for Catalytic Cracking Units," presented at the 15th Annual Symposium on Dynamics of Fluid-Solid Systems of the Division of Industrial and Engineering Chemistry of the American Chemical Society, Cambridge, Mass., Dec. 28-29, 1948; and published in *Industrial and Engineering Chemistry* **41**, 6, 1244-7, June, 1949. Reprinting is by permission of the copyright owner, the American Chemical Society.

This Month's Cover Picture

Operator adjusts focus of sealed beam spotlight on thermopile unit for measuring concentration of catalyst escaping with flue gas through stack on Atlantic's Fluid unit at Philadelphia refinery. Pitot tube flowmeter primary element is at the operator's right

by two streams of air. Under this condition, the intensity of light received by the thermopile corresponds to zero concentration of catalyst. The voltage output of the thermopile may then be adjusted by the potentiometer to the chosen value for E'_0—for example, 4.5 mv.

The output voltage of the thermopile is recorded continuously by a Brown "Elektronik" strip chart potentiometer. If desired, the recorder output may be converted into catalyst concentration by a calibration chart or by a scale mounted near the recording pen.

Measurement of Flow

A reversed type Pitot tube is used as a primary element for measuring the flow rate of the flue gas. The Pitot tube opening is placed at a point at which the gas velocity is maximum. This location was determined by making a velocity traverse through the stack. A five-month test period, involving 20 traverses, showed that the maximum gas velocity, at a fixed level in the stack, is proportional to the average gas velocity over a cross section under steady conditions. At a level 13 ft. above the stack inlet, the point corresponding to maximum velocity was 10 in. from the center.

Correlation of calculated with actual gas velocities under considerably varying operating conditions during the test period showed the deviations to be less than 1% in each case. It was therefore unnecessary to compensate the flow measurements for variations of temperature and pressure encountered during normal operation.

The catalyst fines are prevented from entering the Pitot tube by well-regulated air streams which do not affect the pressure differential across the tube. The tube is connected to a Hagan "Ring-Balance" flowmeter which records directly the flue gas flow rate.

Multiplying System

In order to obtain an indication of the catalyst loss rate at any time, it is necessary to have a device which automatically multiplies the instantaneous concentration into the instantaneous flow rate. The construction of the device follows:

By means of a pair of Selsyn motors, the bridge-balancing wheel of the Brown potentiometer is coupled to a cam which is in the housing of the ring balance flowmeter. A cam follower which is constrained to move in a fixed radial direction rides on the rim of the cam. The contour of the cam corresponds to the empirically-obtained relation between concentration and thermopile voltage output represented by Equation 1, above.

The distance of the cam follower from the center of the cam is proportional to $k \log E'_0$ when the thermopile voltage output is E_0. This position of the follower corresponds therefore to zero concentration. When the voltage output is E, corresponding to the concentration c, the distance of the follower from the center of the cam is proportional to $k \log E'$. Therefore the radial displacement of the roller from the zero position is proportional to concentration c according to the equation.

The flue gas, ring-balance flowmeter carries two recording pens: one for the flow rate and the other for recording the product of the flow rate and any quantity which may be fed into the instrument in the form of linear displacement. If this linear displacement is made proportional to catalyst concentration by the cam arrangement described above, the product pen will record the instantaneous catalyst loss.

An integrating device, built into the flowmeter, sums up instantaneous losses to give the accumulated catalyst loss between any time limits. This value may be read on a counter coupled with the integrator.

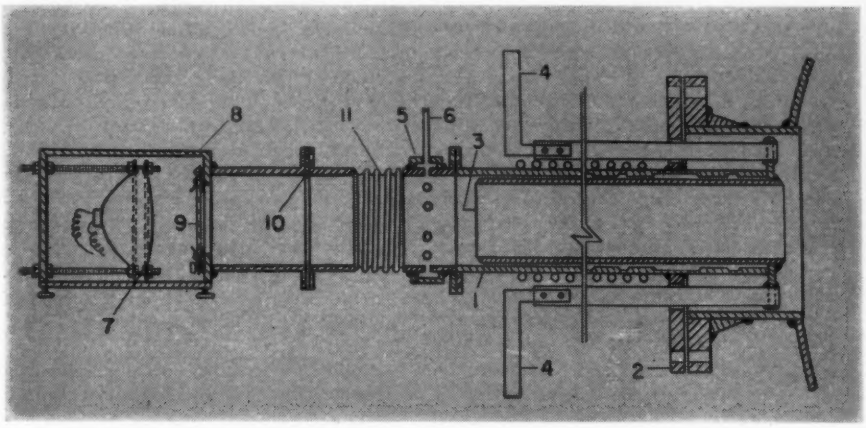


Fig. 1—Light source assembly

Construction Details

The light source assembly is illustrated schematically in Fig. 1. Tube 1 (length, 33 in., I.D. 4 in.) is welded to flange 2. The inner tube 3 may be pushed into the stack by handles, 4, welded to the front end of tube 3. Because the inner tube is heated to about 450° F. while in the stack, the clearance between the two tubes was made about 0.03 in., when both tubes are at room temperature.

It has been found necessary to make the contact area between the tubes small to reduce friction caused by catalyst fines which are caked together by moisture in the flue gas. Two grooved bearing surfaces, at the front end of tube 1, are placed about 8 in. apart to prevent undue sagging of the tube while in the stack. Formation of ice between the two tubes during freezing weather is prevented by a steam coil wound around the outer tube.

Catalyst fines and moisture are prevented from entering the tube by uniform forward flow of pre-filtered air, produced by a series of air entry holes arranged around the circum-

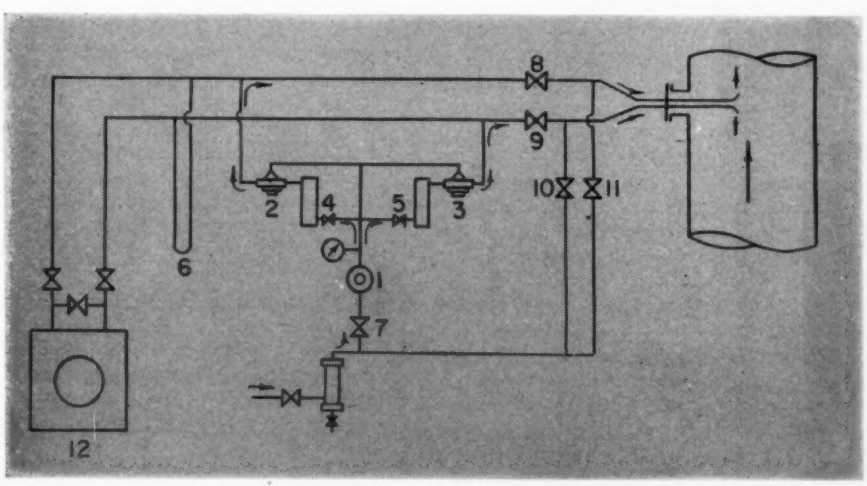


Fig. 2—Purging system for Pitot tube

ference of tube 1 and fed by air channel 5 with air inlet 6, welded directly to the tube.

Among a variety of light sources tried, certain sealed beam spotlights (for example, Type 4535 of General Electric Co.) were found most suitable. By clamping the light around its outer rim 7, mechanical shift due to vibration is reduced to a minimum. Furthermore, the front surface of this type is illuminated quite uniformly; therefore small shifts in position do not affect the thermopile output. Light sources comprising a bulb and separate parabolic reflector were unsatisfactory because the usual severe stack vibrations cause a rapid defocusing.

The housing 8 is separated from the rest of the system by window 9, which allows the housing to be opened for adjustment without disturbing conditions in the tube. The window is cleaned about once every two months by removal after inserting a blind flange at 10. Housing 8 is mounted on an adjustable support so as to arrange proper focus of the light beam on the thermopile. Bellows 11 provides the necessary flexibility.

Voltage regulation to hold the intensity of the light source as constant as possible was first tried with a constant voltage transformer and found insufficient. Satisfactory results were obtained with an electronic voltage regulator (Sorenson, Model 250) provided the load is increased to its rated value by a resistor in parallel with the light source.

The thermopile assembly construction is identical to the one described above, except that window 9 is replaced by a lens and the light source by the thermopile.

Stack Flowmeter

The reversed type Pitot tube used as the primary element in the stack flowmeter consists of two Monel tubes, 5 ft. long with an I.D. of 0.375 in. Catalyst fines and moisture are excluded by well-regulated air streams.

The air purging system is shown in Fig. 2. Filtered air of about 65 psig. is reduced to a nearly constant 15 psig. by regulator 1. The flow is split into two purging streams. The flow rates are held constant by two Moore constant-flow regulators, 2 and 3. These are controlled by the inlet pressure to two needle valves, 4 and 5. An oil-filled manometer 6 is provided for determining the pressure differential across the Pitot tube.

After the differential is read with air supply valve 7 closed, purging air is admitted and adjusted by valves 4 and 5 so that the differential pressure indicated by the manometer is the same as without purging. The flow rate through each tube should be approximately 10 cu. ft./hr. if the velocity in the stack is about 75 fps. Laboratory tests showed that the indicated pressure differential is not measurably affected by variations of $\pm$ 5% in each air stream.

Although purging air will exclude effectively fines and moisture from the interior of the Pitot tube, a deposit of catalyst may gradually build up at the tube openings. This may be removed easily by a blast of air produced by first closing valves 7, 8, and 9, and then opening wide valves 10 and 11.

The differential pressure across the Pitot tube is transmitted from the stack to the control room over a pair of lines 200 ft. long. Tests have shown a line of such length satisfactory for the present purpose. The ring balance flowmeter 12, installed in the control room, is adjusted to read a differential pressure of 1.5 in. of water at full scale. A reading of 1.1 in. of water corresponds to a stack velocity of 75 fps.

Clutch and Cam Arrangement

The bridge-balancing wheel of the Brown potentiometer is coupled to the voltage-concentration conversion cam by a pair of Selsyn motors. Since the chosen type of Selsyn motor was too large to be mounted inside the instrument housings, it was necessary to mount them on the outside. This introduced a complication in the case of the Brown potentiometer since the bridge-balancing wheel is located on the back side of the instrument door.

The problem was solved by devising a mechanical clutch which is engaged when the door is closed and disengaged when the door is opened. The clutch consists of two disks one of which is rigidly mounted on the bridge-balancing wheel. This disk has a conically-shaped depression in the center and an off-axis conical hole. The other disk is connected to the shaft of one of the Selsyn motors. It is constrained to move in an axial direction by a slot, pin, and spring arrangement. This disk carries a blunt conically-shaped pin at the center and a slightly shorter conical pin off the axis. When the door of the instrument is closed, the blunt pin enters its counterpart, thus establishing perfect alignment of wheel and shaft. By a slight rotation of either wheel or shaft, the off-axis pin will find its hole and snap into position by spring action. The pins must be short enough to avoid wedging when the door is opened.

An interlock switch cuts off the power supply to the Selsyn motors when the door is opened. This precaution is necessary to avoid spinning of the Selsyn motors when they are disconnected from the bridge-balancing wheel.

The cam for converting the voltage output of the thermopile into concentration was designed for a maximum concentration of 100 lbs./million cu. ft. This corresponds to a catalyst loss of 4.07 tons/day with a stack diameter of 4 ft. and a flue gas flow rate of 75 fps.

The point on the cam which corresponds to zero concentration (4.5 mv.) is 2.46 in. from the center of the cam; the point which corresponds to 100 lbs./million cu. ft. (1.18 mv.) is 0.51 in. from the center. A displacement of the roller by $2.46 - 0.51 = 1.95$ in. corresponds therefore to 100 lbs./million cu. ft. The contour of the cam between the points indicating zero and maximum concentration was made to correspond to an empirically determined calibration curve, which was practically identical with the curve represented by the equation mentioned above.

Calibration

The catalyst loss recorder may be calibrated through a direct determination of catalyst concentration by means of the thimble method. This is the method commonly used for determining the average concentration of catalyst in the flue gas over a time interval of 2 hours. Since the thimble method may give erratic results, it is advisable to make a sufficient number of determinations, if possible with widely different catalyst concentrations.

The observed concentrations then are plotted against the logarithm of the average voltage output of the thermopile over a period of 2 hours. The average voltage output may be obtained by integration of the curve traced by the recording potentiometer. It was found that the average value determined by this method is practically identical with the value obtained by neglecting the short-time peaks due to the operation of the Cottrell rappers. A straight line may be fitted to the data by the method of least squares.

Installation

For reasons of flow measurement and greater uniformity of catalyst distribution in the flue gas, the Pitot tube and the optical part of the catalyst concentration meter were installed on the stack of the catalytic cracking unit. The optical system was installed at a level which is 13 ft. from the inlet to the stack and 25 ft. from its outlet; the Pitot tube is at a point 18 in. lower. The spot determinations of catalyst concentration for calibration of the instrument were made at the same level.

A platform for installation and maintenance was built around the stack (see photograph). On this platform the air flow regulator for the Pitot tube and the filter for the purging air are located. The Brown potentiometer and the flowmeter were installed in the control room which is near ground level.

Octane Protection Insured By Plant Revamp Program

By D. P. THORNTON, Jr.
Southwestern Editor

AN EXTENSIVE MODERNIZATION project recently completed at the Arkansas City, Kans., refinery of Kanotex Refining Co. will enable the plant to remain competitive octanewise for several years to come. At the same time, it will be able to add some type of catalytic cracking when the octane requirements of motor gasoline become high enough to make such an installation advantageous.

The principal improvements at Arkansas City include a Perco catalytic reforming and desulfurization unit of 4200 b/s/d design capacity, and a greatly enlarged gas recovery plant capable of handling 3500 Mcf/d. A considerable amount of existing equipment from the original gas recovery plant and all of the polymerization unit facilities were utilized in rebuilding the gas plant.

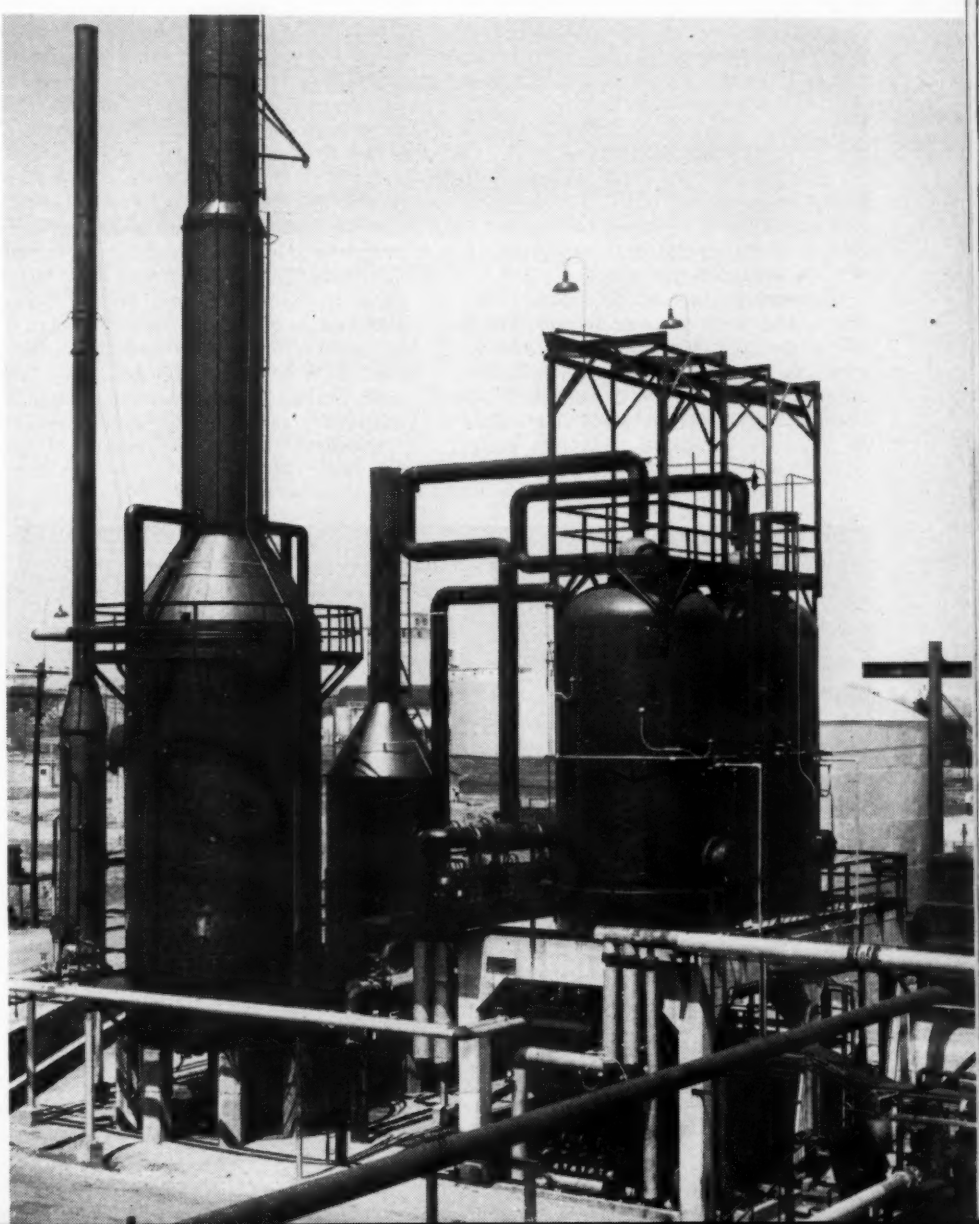
All of the new equipment installed normally would be advantageous with catalytic cracking. Since the Perco unit has been put into operation, a full 400° F. endpoint gasoline meeting or exceeding Great Lakes Pipe Line Co. specifications has been realized, without sacrificing gasoline yield, by processing either a thermally cracked and straight-run blend, or the straight-run alone under mild reforming conditions.

Before the modernization Kanotex found itself in the position of many another "small" refiner today. It could not go much beyond the octane ratings now required for regular gasoline without extensive use of tetraethyl lead, poly gasoline and substantial quantities of such special blending stocks as isopentane. Even so, there was an economic limit to the quality of motor fuel which could be produced even with these aids and also resorting to end point cutting. "We were just going to be caught in a bind over octane number before very long if we did not do something," a plant official commented, when discussing the improvements.

The most obvious solution to the difficulty was to increase the octane number of the base stock either by catalytic cracking or reforming, utilizing as much of the existing plant equipment as feasible. A "community" arrangement between two or more refiners to erect a suitable catalytic unit to process stocks for the group was considered but was not possible for a variety of reasons.

The cost of installing a catalytic cracking unit, regardless of design, in a plant having a crude throughput of 8500 b/d represented a large capital investment. Such a unit would be small (approximately 3500 b/d), would cost $1,500,000, and would require extensive revamping of Kanotex's existing gas recovery and poly plants. Consideration was given to converting the existing thermal cracker to catalytic cracking at an estimated cost of around $750,000. This was discarded because it would provide no facilities for cracking heavy catalytic cycle stock as well as because of the high cost.

Catalytic reforming then was considered. It had several obvious advantages. First, the thermal unit would not be touched, thereby achieving flexibility in that the reformer could process either thermal cracked or straight-run stocks, or their blends. Second, stocks could be desulfurized only, if desired, and would be auto-



Stack, Koch charge heater and superheater, and two Perco reactors at Kanotex's new catalytic reforming unit. Product-to-charge G-fin exchangers are under reactor supports

matically desulfurized if reformed. Finally, gas recovery capacity requirements would be approximately the same as if catalytic cracking were installed. The clinching arguments influencing management's decision, however, were:

The effect of the reforming operation on base stocks, plus increased and better-quality light-ends recoveries from the revamped gas recovery plant, would permit manufacture of motor gasolines definitely competitive octanewise for at least the next five years without special blending agents other than tetraethyl lead.

Operating costs would not be as great as with catalytic cracking.

Cost of the reforming unit would be approximately one-fifth the investment required for a catalytic cracking unit; gas recovery plant cost would be the same.

The process design for the catalytic reformer was made by the Perco Division of Phillips Petroleum Co., the process licensors. Design of the gas recovery plant and engineering design of the reformer was awarded to Koch Engineering Co.

Expectations based on pilot-plant studies have been confirmed in commercial run data accumulated to date. The reforming unit has been used to desulfurize thermally cracked stock with mild, incidental reforming, and to extensively reform and desulfurize a 50-50 blend of straight-run and thermally cracked stock. As this is written the plant is ready to reform straight-run stock.

Reforming the 50-50 blend indicates that both Research and ASTM Motor octane ratings of "finished" gasoline have been improved four numbers each. The differential, or "jump", is approximately the same as for the gasoline formerly made by the plant. Pilot-plant data on reforming straight-run stock indicate that the Research octane improvement will be about ten numbers minimum.

Original Plant

The original Kanotex plant was equipped with a conventional topping unit, taking 400° F. endpoint gasoline overhead, kerosene and furnace oil side-streams, and with topped crude bottoms. It also had a thermal cracking unit, phosphoric acid polymerization unit, clay towers to remove diolefins from cracked gasoline, and a gas recovery plant.

Feed to the thermal unit was prepared in the cracking bubble tower, from topped crude. Also entering this column were evaporator overhead vapors from the thermal cracking unit. This tower split its feed into four streams, as follows: Overhead, a cracked, unstabilized gasoline cut to 430° F. end point; two sidestreams of 20° and 15° API gas oils, and a bottoms product of 13° API heavy stock. A portion of the 20° stream was sold as No. 3 fuel.

The thermal cracker, unchanged, is of three-coil design. Feed to the first coil, 20° API stock, is cracked at 975° F. with 15% conversion per pass. The 15° stock is cracked in the second coil at 950° F. with 10% conversion, and the 13° stock is cracked at 885° F. with 5% conversion.

Coil effluents are combined and pass to the evaporator previously mentioned. Vapors from this vessel pass to the cracking bubble tower and heavy residuum is withdrawn as bottoms. It will be noted that cracking is not severe. Tube sizes will not permit more severe cracking without excessive coke deposition.

Cracked gasoline formerly was treated in clay towers to remove unstable compounds and heavy polymers, then stabilized at the gas plant. Here, as in the case with straight-run stock, the best possible separation was made between butanes and heavier, the stabilized product (containing some butane, however) going to storage. Overhead stabilizer vapors and cracked gas were compressed in two stages to 300 psi., utilizing interstage cooling. Recombined liquid and vapor, mixed with pressure distillate and debutanizer overhead condensate, were charged to another tower for debutanizing, a separation which was not quite complete.

Debutanizer overhead, including dry gas, was charged to a feed preparation tower where, by means of refrigerated reflux, all C_3 and C_4 fractions were condensed for poly plant feed and the overhead rejected to fuel gas. The polymer was depropanized and debutanized in separate steps, and the butane and polymer fractions used for blending purposes. Propane also was rejected to fuel gas.

"Revamped" Plant Processing

New equipment added to the original plant consists of a twin-reactor Perco catalytic desulfurizing and reforming unit. Also, the gas recovery plant was rebuilt, providing facilities to permit retaining propane and heavier hydrocarbons, plus provisions for producing both butane and propane as LP-Gas. Equipment will be described in logical sequence in connection with normal plant flow.

There has been no change from the operation previously described for the topping and thermal cracking units. The refinery charge is a mixture of Kansas crudes. Both sweet and sour are used, although the mixture is "sweet" compared to Texas, Wyoming and other sour oils. Charge to the Perco unit may be either thermally cracked or straight-run gasoline, or a mixture of the two. A flowsheet for this portion of the plant is shown in Fig. 1.

Charge is heat exchanged against reformate "after-fractionator" vapors and again in Griscom-Russell exchangers with reformate leaving the Perco reaction chambers. Final charge preheat to a design temperature of 1050° F. is obtained in a Koch tubular heater rated at 11,500 MBtu per hour. Two reactors, containing bauxite catalyst, have been provided for continuous processing. The reformed stock, leaving the bottom of one of the reactors at approximately 950° F., is exchanged against incoming charge and enters a "prefractionator" at 475° F. Here heavy bottoms (polymers) are rejected to the "after-fractionator". "Prefractionator" overhead vapors enter one of the three existing clay towers in conventional operation for polymeri-

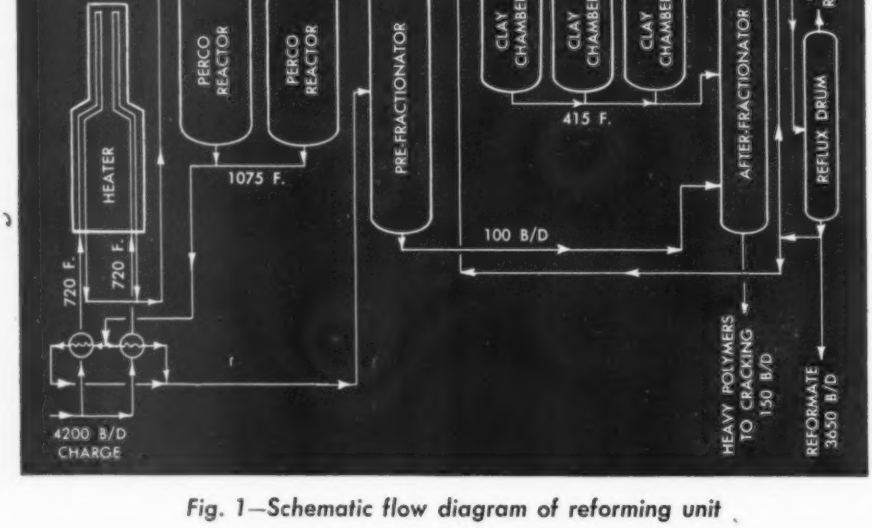


Fig. 1—Schematic flow diagram of reforming unit

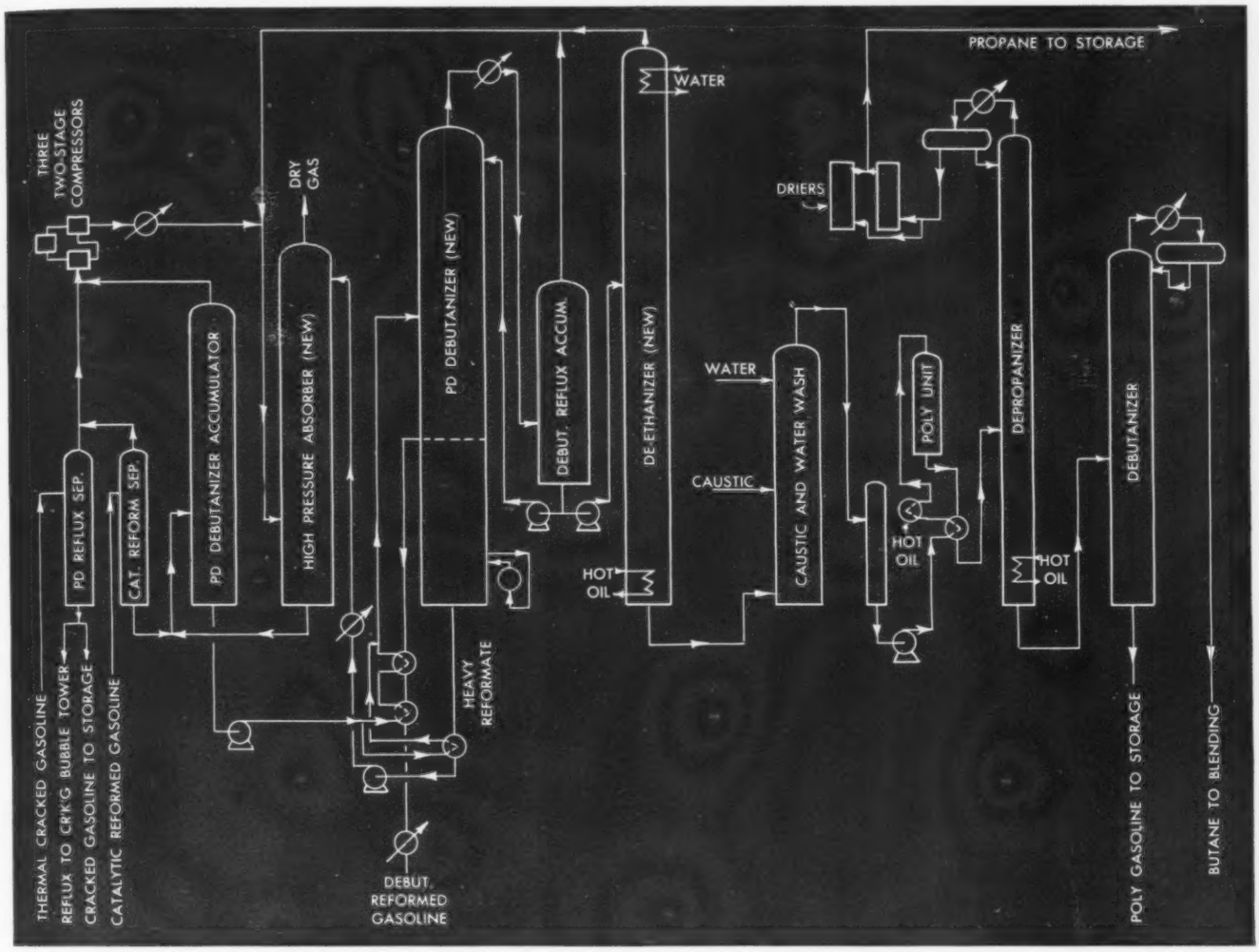


Fig. 2—Gas recovery plant flow diagram

zation of unstable unsaturates, thence to the "after-fractionator" where bottoms are rejected to thermal cracking and specification endpoint gasoline is produced overhead. Overhead from the "after-fractionator," following heat exchange with incoming charge and final cooling, enters a reflux drum where vapors are removed to the gas recovery plant and the bottoms are split into two streams.

The principal stream from this reflux drum—now called reformed gasoline—also goes to the gas plant for stabilizing. The other is used for reflux in both the pre- and after-fractionators.

A steam-air mixture is used for regenerating catalyst in the Perco reactors. Air is provided by a Fuller axial flow compressor designed to supply 844 cfm at 40 psig. Superheated steam, amounting to 11,500 lbs. per hour, is provided by a 4,000 MBtu per hour Koch superheater receiving plant steam at 125 psi. and 353° F. Leaving at 825° F., steam is mixed with the desired amount of combustion air and enters the reactor to be regenerated at approximately 750° F. Flue gas, cooled with steam or water, is wasted to a stack.

Gas from the reformed gasoline reflux drum, as well as that made on the cracked gasoline reflux separator and uncondensed overhead from the P.D. debutanizer, now is charged to the gas recovery and poly unit. A schematic flow diagram of this section of the plant is shown in Fig. 2.

Gas is compressed, as before, to 300 psi. in two stages; compressed vapor and stage condensate are combined. This, plus de-ethanizer overhead, now enters a high pressure absorber where the desired hydrocarbons are absorbed and the residue gas, largely ethane, is rejected to plant fuel. The fat oil is mixed with incoming unstabilized reformate and charged to the reformate debutanizer.

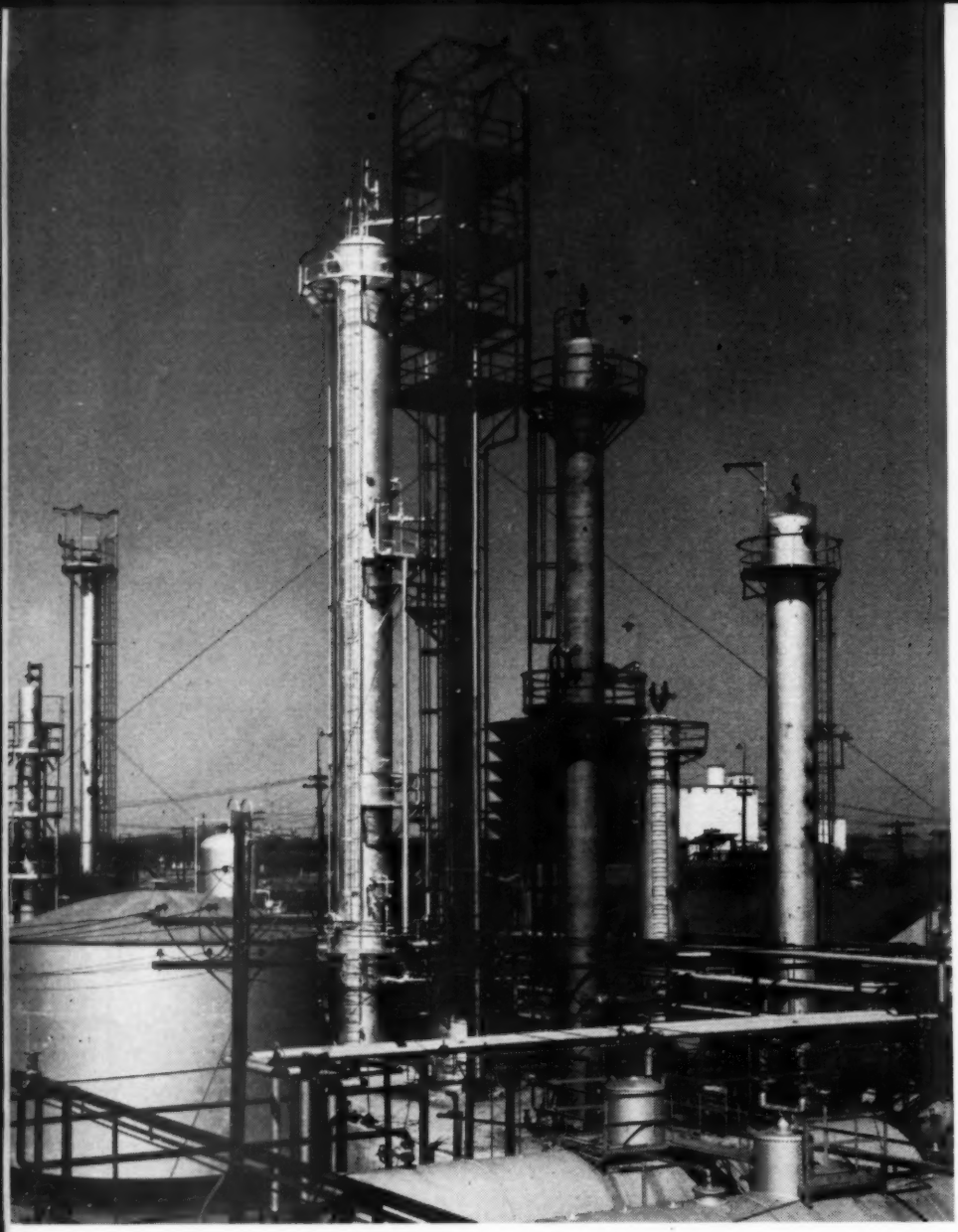
In this debutanizer, a split is made between butanes and pentanes, C_4-free reformate being removed as a side-stream to storage. A portion of the reformate is depentanized in the bottom six decks of the tower and returned to the absorber as lean oil.

Excess debutanizer reflux, containing all C_3's and C_4's, is charged to a de-ethanizer at 600 psi. De-ethanized bottoms are caustic washed and the resulting C_3-C_4 stream is charged to the conventional poly unit. Poly gasoline is depropanized and debutanized in the conventional manner, polymer going to storage as bottoms from the debutanizer and overhead from the two columns, respectively, to propane and butane storage.

Evaluation of Data

Data on commercial operations since revamping has been completed are presented in Tables 1 and 2. These cover, respectively, desulfurization of thermally cracked gasoline and catalytic reforming of a blend containing 48% unstabilized straight-run and 52% unstabilized thermally cracked gasoline. Table 3 shows the results of a pilot-plant run on straight-run only and is considered as showing the minimum effect which catalytic reforming on the commercial unit may be expected to achieve.

The data contained in Table 1, on desulfurization only, were secured before the gas recovery plant was in operation. The improvement in the octane rating of the desulfurized stock over the raw charge is almost wholly attributable to the essentially complete elimination of mercaptans



Gas recovery unit. Towers, left to right, are: caustic and water scrubber, poly debutanizer, reformate debutanizer, de-ethanizer, light ends absorber idle column and poly depropanizer

and reduction of total sulfur. The gain of approximately one number in the clear desulfurized stock and 2.8 numbers in the leaded stock confirms these conclusions.

Due to the fact that the octane improvement on cracked gasoline is less than for straight-run stocks, there is less to be gained from using the Perco unit as a desulfurizer on the cracked stock. Plans of the Kanotex management agree with this conclusion and it is not intended at present to operate the unit on thermally cracked stocks until motor fuel octane requirements advance well above current specifications, at which time the cracked stock will be processed by some one of the several schemes discussed.

The effect of catalytically reforming a cracked and straight-run blend, illustrated with the commercial unit data in Table 2, is masked by the presence of the cracked gasoline, the fact that "severe" reforming was not practiced and that an unstabilized blend was used which contained a considerable quantity of high octane hydrocarbons. Nevertheless a gain between 3 and 4 ASTM octane numbers is apparent in the unstabilized product. Reforming also reduced total sulfur and virtually eliminated mercaptan sulfur.

The losses to gas are not as great as might first appear from inspection of Table 2, apparently 8.2 wt.-%. Included in net C_4 production are butylenes, which will be converted to poly gasoline in the poly plant; butane may be used in blending or sold as LP-Gas. Likewise, under the entry "dry gas," are included propylenes as well as propane; the latter is salable and the former convertible to poly gasoline. Dry gas loss, on the basis of operations shown in Table 2, actually amounts to approximately 3 wt.-% on charge.

Table 3 represents a processing scheme which now is in process of commercial trial at the Kanotex plant. Considerably more sulfur is present in the straight-run than in the cracked stock, as will be apparent on comparing the sulfur content of the raw charge with that of raw cracked gasoline given in Table 1. The desulfurizing effect of reforming is particularly apparent in these data.

The octane improvement also is sharply higher than commercial experience either in reforming the blend of cracked and straight-run or desulfurizing thermal cracked stock, indicating that a gain of at least 10 numbers ASTM or Research may be expected. The "jump" between ASTM and Research ratings will be relatively unchanged from the original plant operation.

Future Operations

Now that the modernization program is complete, Kanotex plans to

TABLE 1—Catalytic Desulfurization of Thermal Cracked Stock

	Charge	Product
Operating Conditions:		
Space Velocity, vol./vol./hr.		1.07
Catalyst Case Inlet Temp., ° F.		757
Pressure, psig.		72
Catalyst		Cyclocel Bauxite
Product Inspection:		
Gravity, ° API	59.8	60.2
ASTM Distillation, ° F.		
IBP	108	110
10%	171	170
50%	249	247
90%	356	344
EP	417	414
Recovery, %	96.5	97.5
Reid Vapor Pressure, psi.	6.6	7.4
Doctor Test	Sour	Sweet
Sulfur Total, wt.-%	0.057	0.034
Mercaptan Sulfur, wt.-%	0.013	>0.0005
ASTM Octane Number:		
Clear	56.1	57.2
1 cc. TEL	65.8	67.8
3 cc. TEL	73.4	76.2

TABLE 2 — Catalytic Reforming of Straight-Run and Cracked Gasoline Blend*

	Charge	Product	Gain
Operating Conditions:			
Space velocity, vol./vol./hr.		1.14	
Heater Outlet Temp., ° F.		985	
Catalyst		Cyclocel Bauxite	
Gas Production, Mcf./hr.		45	
Product Summary:			
Dry Gas, wt.-%		4.7	
Net C_4 Production, wt.-%		3.5	
C_5 + Recovery, wt.-%		92.8	
Carbon Laydown, wt.-%		0.6	
Product Inspection:			
Gravity, ° API	61.3	61.8	
ASTM Distillation, ° F.			
IBP	86	86	
10%	147	145	
20%	177	174	
50%	242	235	
90%	376	370	
EP	432	425	
Recovery, %	95	95	
Reid Vapor Pressure, psi.	11.4	12.9	
Doctor Test			
Total Sulfur, wt.-%			
Mercaptan Sulfur, wt.-%			
ASTM Octane Number:**			
Clear	60.7	64.6	3.8
1 cc. TEL	69.9	74.3	4.4
3 cc. TEL	76.5	79.7	3.2

* Charge consists of 48% unstabilized straight-run and 52% unstabilized cracked gasolines.

** After caustic washing.

TABLE 3—Expectations, Catalytic Reforming of Straight-Run Gasoline*

	Charge	Product
Operating Conditions:		
Space Velocity, vol./vol./hr.	...	2.04
Catalyst Case Inlet Temp., ° F.	...	1021
Pressure, psig.	...	50
Catalyst	...	Cyclocel Bauxite
Product Summary:		
Dry Gas, wt.-%	...	8.5
C_4 paraffins, vol.-%	...	5.9
C_4 olefins, vol.-%	...	2.3
C_5 + gasoline, vol.-%	...	85.0
Carbon Laydown, wt.-%	...	0.6
Product Inspection:		
Gravity, ° API	68.2	65.4
ASTM Distillation, ° F.		
IBP	99	116
10%	140	154
50%	203	203
90%	258	269
EP	320	344
Recovery, %	96	96
Reid Vapor Pressure, psi.	8.2	5.3
Doctor Test	Sour	Sweet
Total Sulfur, wt.-%	0.140	0.024
Mercaptan Sulfur, wt.-%	0.007	0.000
UOP K Factor	12.20	12.05

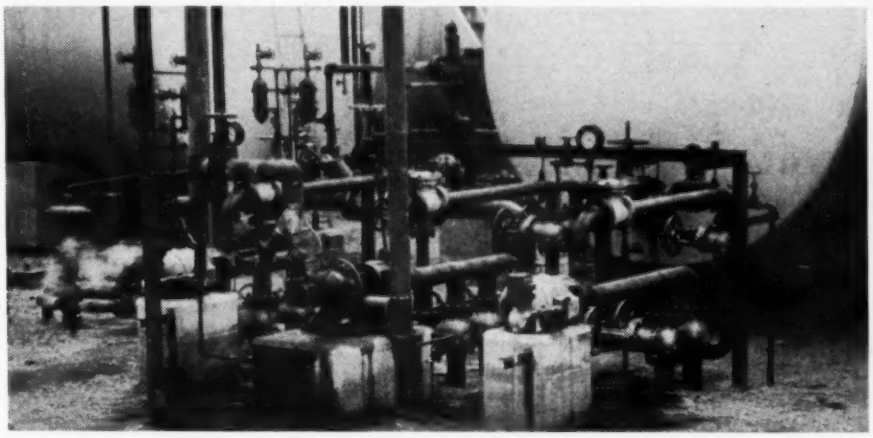
Octane Number:	AS TM	Re- s'rch	AS TM	Re- s'rch
Clear	57.4	57.6	60.8	62.2
1 cc. TEL	60.4	61.0	68.8	73.0
3 cc. TEL	68.5	70.6	78.8	81.3

*Pilot plant data.

use two principal processing schemes, depending on the particular situations which may exist. One involves the reforming of an approximate 50-50 blend of cracked with straight run, similar to the operation shown in Table 2, with possibly more severe reforming than the present data indicate.

The other probably will be the "normal" operation, featuring reforming of straight-run only, as in Table 3, with stabilization of thermally cracked stocks after clay tower treatment. In this operation, flow sequence will depart in a few details from that previously described.

A third possible processing scheme involves a "blocked operation" of desulfurizing the cracked gasoline and reforming the straight run stock. Should octane number competition render this step desirable at some time in the future, it may be accomplished by segregating the charge stocks and products and alternating the process. In order to decrease process tankage and to eliminate variations in gas plant load some consideration may be given toward installing a third catalyst chamber to allow continuous desulfurization of the cracked gasoline while reforming the straight run gasoline.



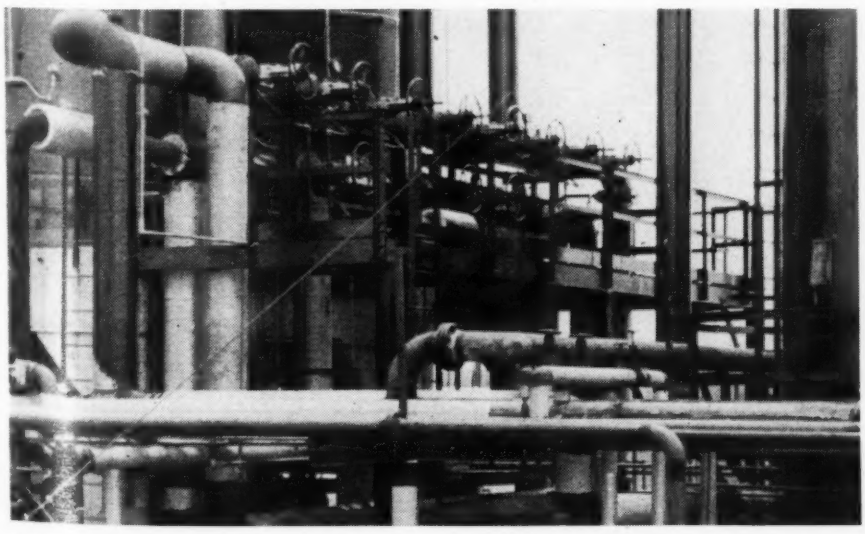
One turbine driven and two electric pumps transfer cracked and straight-run gasoline to charge tanks at Perco unit. Manifolding permits transfer of any desired mixture of the two stocks

In the second, or "normal" operation, thermally cracked gasoline will be brought directly from the cracking bubble tower reflux separator to the clay towers (Fig. 1). From the clay towers, the product will flow to the after-fractionator. It is as yet undecided whether or not the pre-fractionator will be bypassed in this operation.

This arrangement, incidentally, is unique with Perco catalytic reforming units. Most plants have scrapped their clay towers upon installing either reformers or catalytic cracking. The thermally cracked gasoline, however, apparently contains a considerable amount of diolefins which are removed in the clay towers and after-fractionator as heavy polymer.

The clay tower step has been bypassed experimentally in treating cracked gasoline, whereupon the cost of gum inhibitor required in Kanotex's finished gasoline increased approximately $50 per day. (Clay treatment of straight-run shows only negligible improvement in this respect.) Apparently diolefin removal as polymer more than counterbalances the condensation of hydrogen sulfide with olefins to produce low molecular weight mercaptans, a theoretically possible reaction which may occur to a limited extent during clay treatment.

Straight-run gasoline will be brought directly to the charge tanks of the Perco unit from the topping plant. Operating conditions will be similar to those given in Table 3. Flow from the Perco unit, however, will by-pass both the pre-fractionator and clay towers, entering the after-fractionator directly to mix with the cracked stock previously mentioned. Balance of flow sequence will be as indicated in Fig. 1, the blended product being cut to end point in the after-fractionator and stabilized at the gas plant, as indicated in Fig. 2.



Simple, efficient arrangement of reactor manifolding is used at the Kanotex plant. Top row of valves controls charge flow to the two reactors in background; bottom row controls regeneration steam-air mixture

Acknowledgment

The author is particularly indebted to F. A. Deering, vice president in charge of operations, Kanotex Refining Co. and T. F. Kreipe, Perco Division, Phillips Petroleum Co., for providing operating data and technical information used in preparing this article and their helpful criticism of the final manuscript.

Corrosion Protection for Tanks By Reinforced Gunite Linings

Reinforcing with steel mesh in the application of guniting has provided a successful means of protecting storage tanks from corrosion, overcoming spalling which occurred when a thinner, non-reinforced gunite lining was used. Details of installation of the reinforcing are given. Careful selection of materials and application of the gunite by experienced crews are essential to serviceability. Gunite cannot be used to plug leaking tank bottoms and shells. Materials and man-hours are given for typical installations.

APPLICATION of reinforced gunite on affected areas has been found by Humble Oil & Refining Co. the most effective method for protecting storage tanks against interior corrosion, from the standpoints of first cost, maintenance and serviceability.

In general the gunite linings as installed by Humble cost from 50 to 90% as much as replacing the steel plates and structural members but they will give indefinite service with negligible repairs.

The reinforcing is a most important part of the Humble procedure. It consists of ¼-in. diameter bars and 3 x 3 in., by 10 gauge, plain mesh, installed to furnish additional bond between the gunite lining and the tank surface, and to support and distribute the loads on the gunite.

Typical reinforced gunite installations are: (1) roof protection; including the underside of the roof, the rafters, girders, columns and inside of shell down to an elevation 3 ft. below the top of the shell; (2) bottom protection; including the bottom, inside of shell and the columns to a height of about 18 ins. Protection of the entire tank interior has been found practical for tanks in rundown service and for other vessels of moderate size in naphtha service.

A recent survey of 87 gunite-protected tanks at the Baytown refinery by the Humble maintenance engineering and inspection department showed the gunite protection has proved remarkably free from maintenance during approximately eight years of experience. One case was found of a tank with unreinforced gunite lining which gave 10 years of service, with moderate repairs on only two occasions. Fig. 1 shows the absence of corrosion on the crown sheet of a rundown tank after six years of gunite protection.

Early applications of gunite at the Baytown refinery were unreinforced linings in ¼-in. thickness only, due to the difficulty of supporting a greater thickness without reinforcing. Inspection records on tanks with these linings showed occurrences of spalling. Inspection of the tanks with reinforced linings showed complete protection of the metal. In only one case had the gunite failed exposing the tank plates and in one case the reinforcing was exposed. It is believed these cases were due to the thermal stresses produced when steaming the cold tanks during gas freeing operations. Repairing the break caused by the removal of door sheets for the inspection was all the repair work required to maintain the reinforced gunite protection, except in the two cases noted.

A rundown tank, part of a process unit being dismantled, which had been protected by reinforced gunite for six years, showed no noticeable deterioration of the gunite surface and no corrosion of the steel plates.

Inspection of a tank used for storing naphtha, the entire interior of which was gunited in 1940 except the original concreted steel bottom, showed the gunite liner to be in very good condition. The exposed steel around the opened door sheet indicated complete protection against corrosion. The corrosion loss on the shell nozzles did not warrant replacement. Prior to guniting, average tank roof life in this service had been four years.

Gunite protection as applied at the Humble Baytown refinery is solely for the protection of existing sound metal and not for rebuilding severely corroded areas. "Gunite cannot be used to plug leaking tank bottoms or shells", emphasizes the report of the Maintenance Engineering and Inspection Department.

The success of the Baytown program for gunite protection of tanks is due to the careful methods taken for inspection and preparation of the tanks and the installation of the reinforcing, as well as the actual application of the gunite. Recommended procedure is given in a recently issued bulletin for the refinery personnel, entitled "Gunite Application in Storage Tanks". The following is a review of this bulletin:

PREPARATION OF TANKS

Preparing the tank surfaces to receive a lining of gunite consists of cleaning the surfaces of scale, foreign matter and oil deposits, then sandblasting to the bare metal.

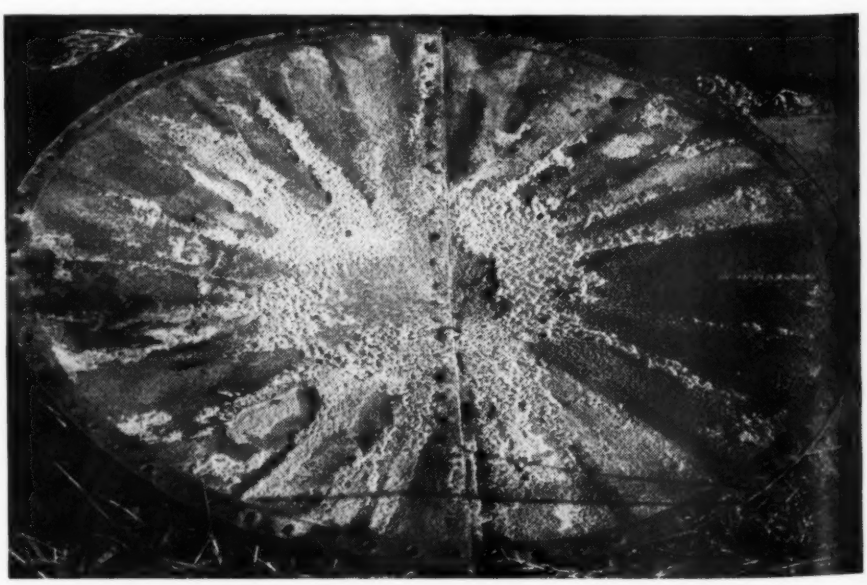


Fig. 1—Crown sheet of a rundown tank, gunite protected for six years; with gunite lining removed to show absence of corrosion

Cleaning the interior precedes the inspection that determines the necessity for, and economics of, applying gunite. After gas-freeing the tank, one or more door sheets are removed. Interior surfaces are then washed down with fire hose to remove loose scale and foreign matter. The scale, foreign matter and oil sludge are removed from the tank through a door sheet opening.

A portable scaffold is then erected inside so that the roof and shell may be drilled and measured at sufficient locations to determine the corrosion rate in typical areas or sections. If the corrosion rate indicates a service life of less than 10 years, gunite protection is usually considered justifiable.

Gunite protection usually is not attempted on roofs where the steel has lost two-thirds of its original weight. New steel usually is gunited when the corrosion rate indicates an expected service life of five years or less. Gunite is not applied where calculations and other considerations indicate that corrosion has progressed to such an extent that the tank members are not satisfactory for the additional load. Method of calculation and allowable stresses used are as specified in Part I, Design Specifications, API Standards Nos. 12-A, *Standard Tanks with Riveted Joints;* and 12-C, *All-Welded Oil Storage Tanks.*

After the application of gunite protection has been decided upon, the following utilities are made available at the tank site:

Air: Compressed air at sufficient pressure to insure a minimum of 65 psig. at the gunite nozzle.

Steam (if available): 150 psi. steam for jet cleaning of rebound gunite from tank bottom during cleanup, and for maintaining effective curing temperature during freezing weather. While steam is desirable for these operations, it is not essential and other means may be used.

Electricity: 3-phase, 60-cycle, 440 volt, alternating current for welding equipment; and single-phase, 60-cycle, 110-120 volt, alternating current for lights.

Water: for washing tank and for filling it to float rafts; and fresh water for mixing gunite. Salt water may be used for washing or filling tanks; however, the water for mixing gunite must not contain elements detrimental to the cement mixes.

In addition to the utilities, the following services are required: adequate lights, suitable roadway to tank site, one or two openings in tank roof for access and ventilation, scaffolding for use in applying bars, mesh and gunite to underside of roof patches.

When roofs and shells are to be gunited, it is preferred to work from rafts floating on water in the tank. A raft may be moved easily as the work progresses, and a fall from a raft does not incur the danger of serious injury to a workman as would a fall from scaffolding. However, during hot weather the high humidity of the atmosphere inside a tank filled with water may become so objectionable as to make the use of scaffolding desirable.

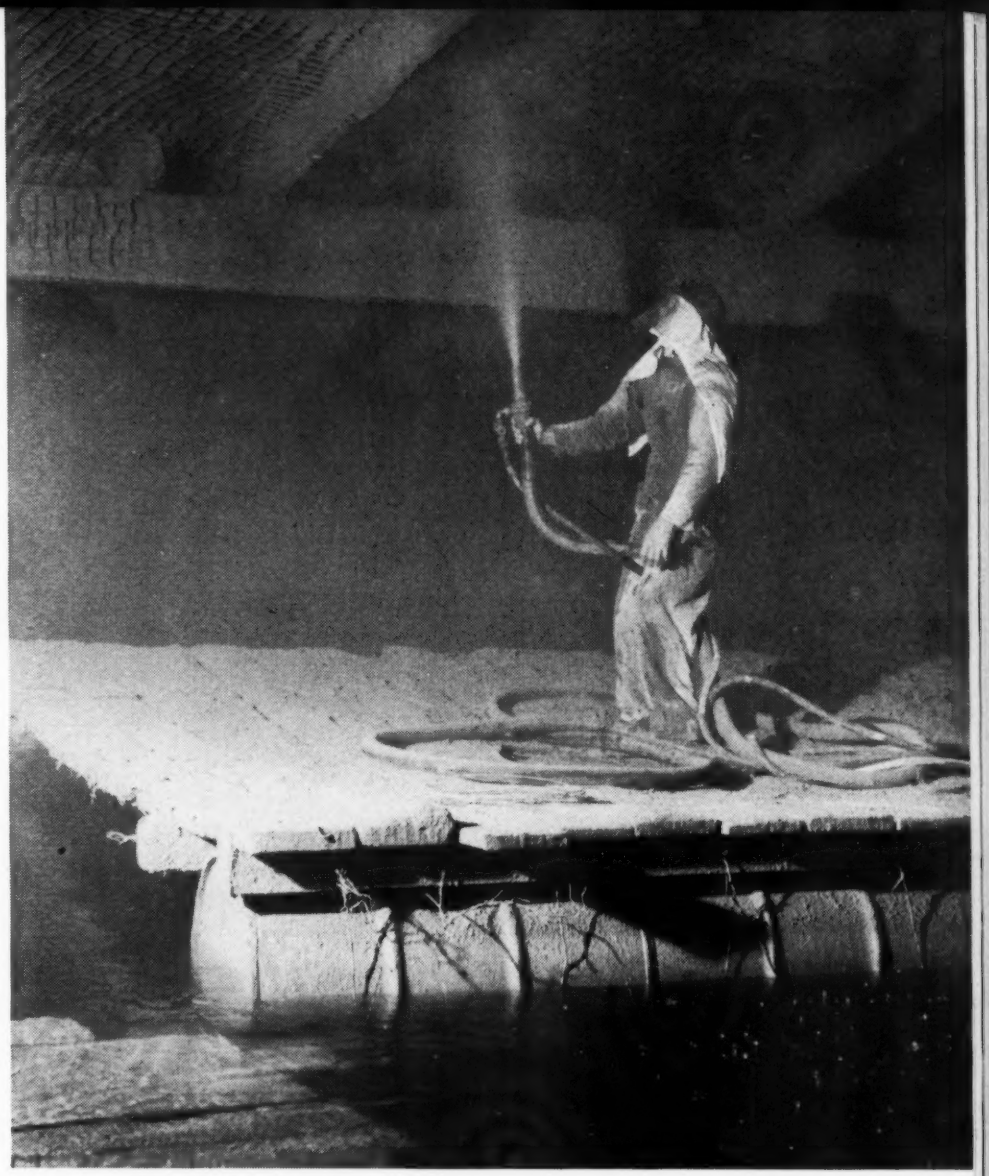


Fig. 2—Applying gunite to roof and rafters of tank interior, from a raft floated on water inside the tank. Reinforcing can be seen in the upper left hand corner

The rafts are constructed of rough 2 x 6-in. decking over a framework of 4 x 4 in. members secured to 55-gal. steel drums. The usual raft size is 10 x 15 ft. The rafts are prefabricated and placed in the tank through a door sheet opening upon completion of cleaning. They are taken from the tank when the door sheets are again removed for cleanup work. If the door sheets are not removed, they can be dismantled and removed through manways. Fig. 2 shows a guniting operation from a raft.

The scaffolding, when used, is constructed on wheels or rollers to facilitate movement as the work progresses.

Sandblasting

When the application of gunite has been decided upon, all areas to be protected are then sandblasted to remove additional scale or foreign matter still attached to the surfaces. Sand with a nominal moisture content will remove these deposits and is considered satisfactory. However, dry sand is required to polish the surfaces bright.

A crew of three men is required for sandblasting. One man screens the sand, loads and operates the machine; one man remains on top of the tank adjusting the hose and relaying signals from the man inside the tank, who operates the sandblasting nozzle. The crew member operating the nozzle should be relieved periodically. The sandblasting crew usually works from the floating raft, when working on the roof and upper shell of the tank.

The sandblasting crew uses much of the equipment later used by the gunite crews. The gunite machine used in most instances serves equally well for sandblasting when a hood is placed over the air supply nozzle and feed wheel. This hood permits the use of damp sand for sandblasting and is installed only when sandblasting is being performed. On

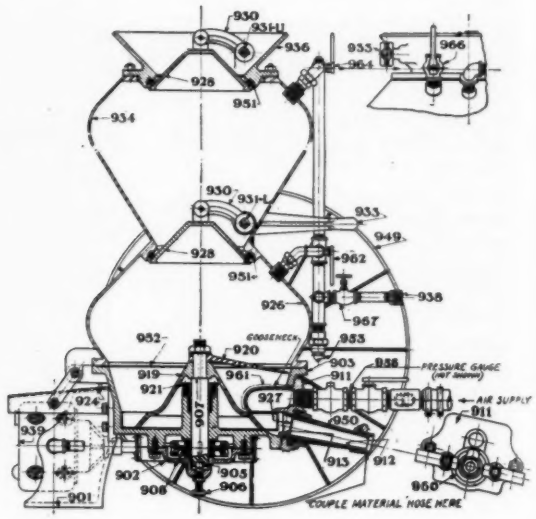


Fig. 3—Left above: Type N-1 gunite machine, showing both sandblasting and guniting nozzles connected to respective hose. Right above: sectional elevation of gunite machine; right below: parts list

Parts List

901—Foot
902—Worm Gear Case
903—Base
905—Upper Thrust Button
906—Adjusting Screw
907—Feed Wheel Shaft
908—Worm Gear
911—Outlet Valve Body
912—Outlet Valve (Rubber)
913—Outlet Valve Body Liner
919—Feed Wheel
920—Agitator
921—Feed Wheel Shaft Packing Gland
924—Air Motor Shield
926—Lower Tank
927—Outlet Valve Ring
928—Cone Valve
930—Cone Valve Arm
931L—Lower Cone Valve Shaft
931U—Upper Cone Valve Shaft
933—Cone Valve Lever
934—Upper Tank
936—Upper Cone Valve Section
938—Blowout Connection
939—Air Motor
949—Wheel
950—Funnel Flange (Metal)
951—Cone Valve Gasket
952—Base Gasket
953—Auxiliary Air Connection (Hose)
956—Air Pressure Gage
961—Hood
962—Lower Chamber Valve
964—Upper Chamber Valve
966—Exhaust Valve
967—Blowout Valve

most tanks it is not economical to use smaller than the No. 1 Type gunite machine. Fig. 3 shows the gunite machine, sectional elevation and parts list.

Sandblast service, four-ply rubber hose of 1-in. or 1¼-in. diameter is used as the material hose for sandblasting and guniting. Larger sizes are used when working on the bottom of the tank with adequate air pressure. Average service life of the hose is six to eight months. A ⅜-in. diameter, manganese alloy sandblasting nozzle is generally used. The quantity of sand and number of man-hours required for sandblasting is approximated in Table 1.

INSTALLING REINFORCING

Following an inspection of the sandblasted surface, the tank is ready to have reinforcing installed.

To furnish additional bond between the gunite lining and the tank surfaces, and to support and distribute the loads on the gunite, reinforcing consisting of ¼-in. diameter bars, and 3 x 3-in., by 10-gauge, plain mesh is installed.

Crew and Equipment

A five-man crew is used to erect reinforcing in the storage tanks. Two welders and two helpers operate inside the tanks, with one man remaining outside to adjust lines, secure materials, and regulate the welding machines. As in sandblasting, the crew usually works from the floating raft when erecting reinforcing for roof and shell protection.

Equipment required for installing reinforcing is rated for light duty. Two 200-amp., 40-volt, 1400-rpm. direct current welding generators are used for tackwelding reinforcing bars and roof opening rewelding. A jig is used to facilitate the prebending of sections of mesh to rafter and other shapes. Conventional hand equipment is used for cutting and tying the reinforcing.

Materials and Man-Hours

Both galvanized and plain reinforcing materials have been used in the guniting work, with no noticeable difference in the protection provided. Reinforcing bars ¼-in. in diameter are tackwelded to the tank, using 5/32-in. arc welding electrodes conforming to American Welding Standards, Spec. E-6010. A network of 3 x 3 in., by 10-gauge, plain steel mesh in 5-ft. widths is tied securely to the bars at intervals of about 9 ins. with 16-gauge wire. Table 2 shows the average quantities of material and number of man-hours required on typical installations.

Installation Details

On the underside of the roof of the tank, the ¼-in. diameter bars are placed radially not over 15 ins. apart and tackwelded on 18-in. centers to the roof. In addition, one ¼-in. diameter bar is placed on each side of each rafter approximately 2 ins. from and parallel to the rafter, and tackwelded on 18-in. centers to the roof.

The steel mesh is cut to fit be-

TABLE 1—Man Hours and Materials for Sandblasting

Extent	Matl. or Labor	Tank Diameter 60 ft.	Tank Diameter 117 ft.
Preparing roof	Sand (yds.)	15–18	45–50
Preparing roof	Man-hours	130–140	400–420
Preparing bottom	Sand (yds.)	8–10	25–30
Preparing bottom	Man-hours	35–45	110–130

tween rafters, and tied to the ¼-in. bars at intervals of 6 ins. with 16-gauge wire. The rafters are enclosed by mesh bent to a U-shape, properly fitted, and tied securely to the ¼-in. diameter reinforcing bars paralleling the rafters. Both reinforcement and mesh are discontinuous at the safety seams; that is, the bars and mesh extend to the seams but not across them. Columns, beams and girders are wrapped with 3 x 3 in., by 10-gauge, steel mesh, cut and bent to their respective shapes, and the mesh is tied securely at the joints with 16-gauge wire. Fig. 4 shows the installation of reinforcing mesh and bars at junction of roof and shell.

On the shell of the tank, the ¼-in. diameter bars are placed vertically on 18-in. centers and tackwelded to the shell about every 18 ins. The 5-ft. widths of steel mesh are tied securely to the bars. Reinforcement covers door sheets but is cut at edges of door sheets to allow removal.

At the junction of the roof and shell (except along circumferential safety section) and at the junction of the bottom and the shell, 3 x 3 in., by 10-gauge, steel mesh in the form of a 12 x 12-in. angle is installed and tied to the reinforcing bars on the side and top, or bottom, as the case may be.

To facilitate fastening mesh and applying gunite, the bars are sprung out from the tank plates between points of attachment. When tying mesh to the bars, adjacent sections of the mesh are overlapped at least 3 ins. along each edge. No sag is permitted in the mesh.

On the bottom of the tank, the ¼-in. diameter bars are placed on about 24-in. centers forming nominal 24-in. squares. The steel mesh is laid upon the bars and tied at the corners of squares with 16-gauge wire. The bars are not attached to the bottom of the tank. The steel mat (bars and mesh) is lifted just ahead of the gunite stream to the center of the gunite layer.

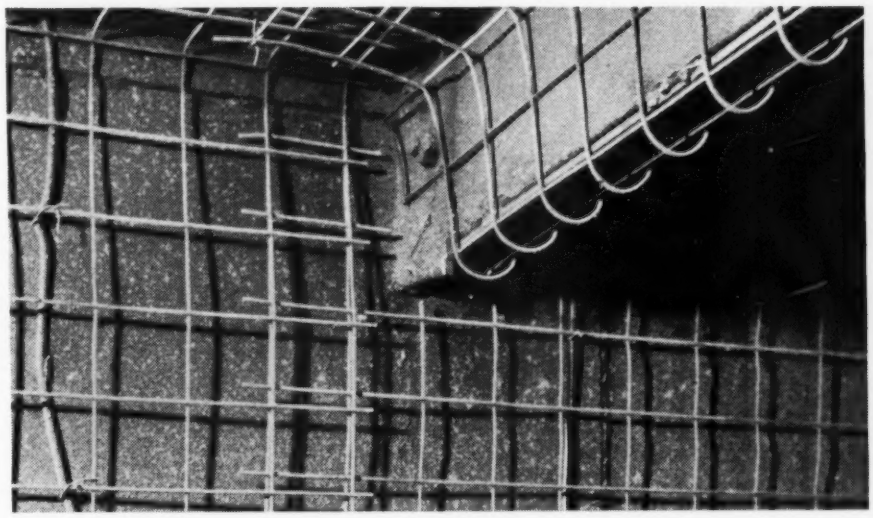


Fig. 4—Installation of reinforcing mesh and bars at the junction of roof and shell, and around rafters, in tank interiors

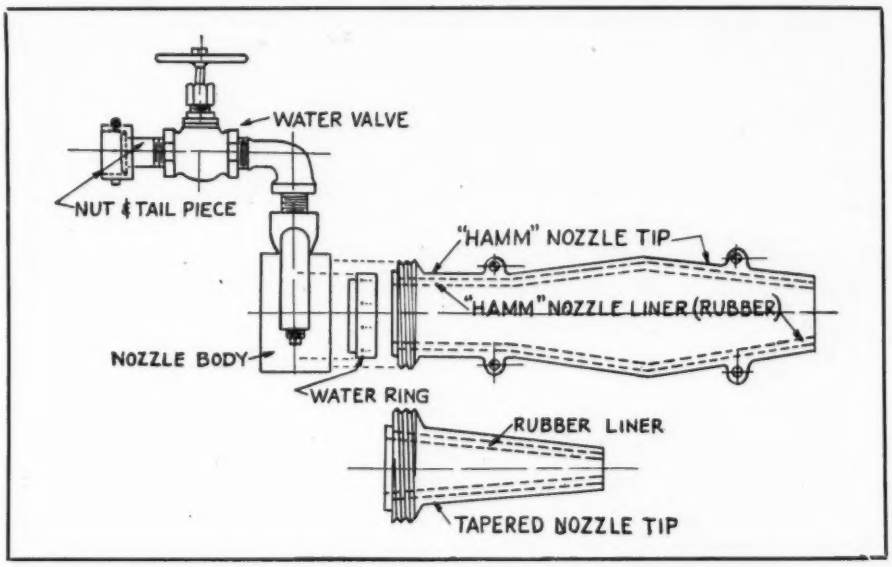


Fig. 5—Two styles of gunite nozzles

APPLICATION OF GUNITE

Dependable protection through guniting depends to a great extent on the selection of the materials for the gunite and its application by experienced crews.

The crew applying the gunite is usually composed of seven men; a foreman, two nozzlemen, machine operator and three laborers. Two men proportion and mix the sand and cement, and pass the mixture through a ½-in. screen; one man loads the gunite machine; one man operates the machine; one nozzleman remains outside the tank to arrange the hoses and relay instructions from the nozzleman operating the gunite nozzle inside the tank. The two nozzlemen rotate duties periodically, thus reducing the time each spends inside the tank.

The equipment used for gunite application is the same as used for sandblasting except for the nozzle, and the addition of a water pump and water hose. A 1-in. guniting nozzle with renewable rubber liner is used. With proper inspection the nozzle lasts one year or longer, the rubber lining being replaced usually after about 300 hours of service. Fig. 5 shows two styles of gunite nozzles.

Either a small, electrically-driven, centrifugal pump, or a reciprocating pump (5½ x 3½ x 7 ins.) is used to assist in maintaining at the gunite nozzle a minimum water pressure of 20 psi. in excess of the air pressure at the nozzle. This excess water pressure prevents the water jets in the nozzle from becoming clogged and damaged beyond repair.

The hose used for the mixture of sand and cement is the same as is

TABLE 2—Materials and Man Hours on Typical Reinforcing Installations

Extent	Materials and Labor	Tank Diameter 60 ft.	Tank Diameter 117 ft.
Roof Protection	Reinforcing bars, ft.	4000	18,000
Roof Protection	Steel Mesh, sq. ft. (based on area + 15%)	6400	22,000
Roof Protection	Tie-wire, lbs.	40	70
Roof Protection	Electrodes, lbs.	20	80
Roof Protection	Man Hours	360	800
Bottom Protection	Reinforcing bars, ft.	4100	15,000
Bottom Protection	Steel Mesh, sq. ft. (based on area + 15%)	3850	13,500
Bottom Protection	Tie-wire, lbs.	20	60
Bottom Protection	Electrodes, lbs.	2	5
Bottom Protection	Man Hours	60	150

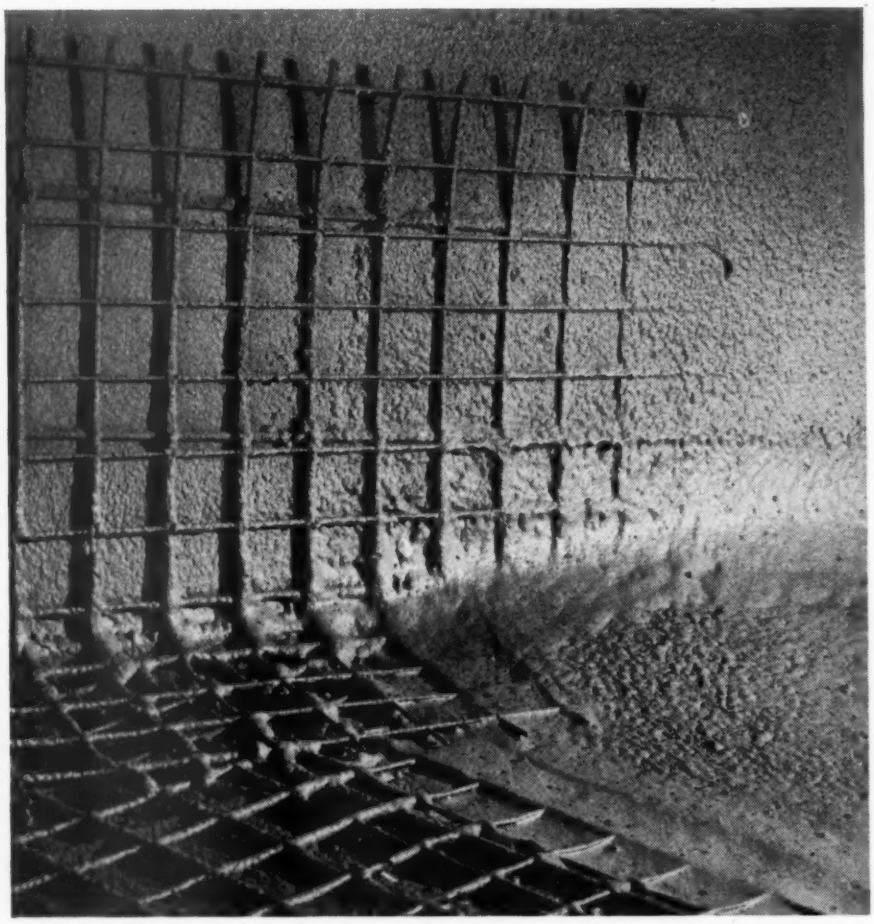


Fig. 7—Gunite partially applied to junction of shell and tank bottom

used in sandblasting. Hose used for water where the pressure is up to 100 psig. is ½-in., air service, rubber hose. Air service hose is used because of its high resistance to external wear and proper pressure rating.

The gunite mixture consists of one part cement to three parts of fine aggregate. The cement used is an approved brand conforming to the Specifications for Portland Cement, ASTM Spec. C-150-44, Type III or I, unless otherwise specified. The aggregate used is a high silica sand consisting of clear, hard, strong, durable grains, washed free of sticks, mud and other deleterious material. Other deleterious material, for the purpose of this specification, is defined as shown in Table 3. Sand used must fall within the following grading:

Passing	% by Wt.
No. 4 Sieve	95-100
No. 16 Sieve	50-90
No. 50 Sieve	5-30
No. 100 Sieve	0-8

The water used is clean, free from oil, salt, acid, alkali, vegetable matter or other substances injurious to concrete. On typical installations the average amounts of cement, sand and man-hours are used as shown in Table 4.

While applying gunite, the nozzleman holds the nozzle at as near right angles to the surface being covered as possible, with the nozzle about 3 ft. from the surface. In order to produce true surfaces the nozzleman keeps the stream of mortar continuously moving, placing the gunite in thin layers, thereby avoiding lumpiness.

Gunite is applied to an average thickness of 1 in. on the shell of tanks, to a minimum thickness of 1¼ in. on the roof and structural members, and to a minimum thickness of 2 ins. on the bottom.

The application of gunite to the roof, rafters, girders and columns is started at the center of the tank working from a floating raft. First the rafters are covered, then the area between rafters is filled. This reduces chance of spalls, as the rafters gain considerable strength before the area between rafters is filled. As much of the roof is completed as can be reached with this head-space. Then the water level in the tank is lowered and the remainder of the roof work is completed. A rebound loss of 30-35% is experienced in applying gunite to roof and shell. The rebound must be removed from the tank bottom before guniting.

The application of gunite to the shell is started at the top and applied from the rafts in about 5-ft. strips completely around the tank. Installation of gunite with water in the tank at the maximum practical level insures maximum stress on the roof, structural members, and shell. Thus, a compressive stress exists in the concrete with the tank empty, or filled to an equivalent height with oil.

After the work is completed on the roof, shell, and other structural members, including closing and guniting the roof openings, the tank is drained and the door sheets are removed. The rafts are removed through these openings. The bottom of the tank is cleaned of all waste from the sandblasting and guniting of the roof and shell, using high pressure water and steam, if available. The bottom is sandblasted to bare metal and spent sandblast sand is removed. The reinforcing is laid on the bottom, and installed around the bottom of the columns and shell. Gunite is then applied to the bottom and lower parts of columns and shell, as illustrated in Fig. 7. As the final step in the installation, the door sheets are redriven, reinforcement installed, and gunite applied.

Curing the gunite is usually performed by spraying the gunited surfaces with water at two-hour intervals for the first 48 hours; 72 hours usually elapse between completing the gunite application and placing the tank in service. When the temperature has dropped below freezing after the gunite was applied, steam is used to maintain proper curing temperature. The steam condensate on the tank members furnishes the curing water.

TABLE 3—Definition of Deleterious Material

Material	Max. % by Weight
Clay lumps	1.5
Coal and/or lignite	1.0
Material passing No. 200 sieve	2.0
Shale, alkali, mica, coated grains, soft and flaky particles	1.0

TABLE 4—Materials and Man Hours for Gunite Application

Extent	Material and Labor	Tank Diameter 60 ft.	117 ft.
Roof Protection	Cement (sacks)	200–240	700–850
Roof Protection	Sand (yds.)	22–26	78–94
Roof Protection	Man Hours	250–300	950–1100
Bottom Protection	Cement (sacks)	150–180	500–600
Bottom Protection	Sand (yds.)	16–20	56–67
Bottom Protection	Man Hours	200–250	800–1000

ROTAMETERS—

Their Use and Application in Plant-Scale Refinery Operations

By T. M. HOFFMAN, Jr., Senior Mechanical Engineer
Humble Oil & Refining Co., Engineering Division, Baytown, Texas

ROTAMETERS have been used extensively in petroleum refinery laboratory work for many years. The tapered glass tube type of instrument with the etched scale is a familiar sight around pilot unit work. Rarely, however, has the rotameter been accepted by engineers or operators for refinery process units. The possibility of accidental breakage accompanied by the release of inflammable materials kept this instrument in the background while the orifice meter became the industry standard.

The possibilities of the device were not considered seriously until one manufacturer introduced a rotameter in which the fluid measured was completely enclosed in a metal casting. In one model a float rod extension moved the soft-iron core in an impedance bridge-type electrical transmission system. The instruments still were not employed extensively, however, since most oil refinery men favor pneumatic transmission over the electrical type.

The rotameter type pneumatic transmitter was developed when it was found possible to transfer magnetically the motion of the float to the transmitter mechanism. The float extension in this rotameter rises inside a stainless steel tube within the instrument case. Two opposed bar magnets are mounted on the extension and the motion is picked up by a magnetic follower. The instrument employs the standard range of output air pressure, and can be used in conjunction with any standard make of pneumatic receiver-type recorder or recorder-controller.

Advantages and Disadvantages

The rotameter type of primary element has some inherent advantages over the orifice plate which make it an ideal device for certain applications. The instrument can be made practically immune to changes in the viscosity of the fluid metered by proper design of the float. The upflow metering tube is self-venting, and is capable of handling fluids containing solid particles which would stack up behind an orifice plate. The float position is linearly related to the rate of flow and an evenly-divided chart is used. The rotameter has a rangeability of 10 to 1 as compared to a useful orifice meter rangeability of about half this value.

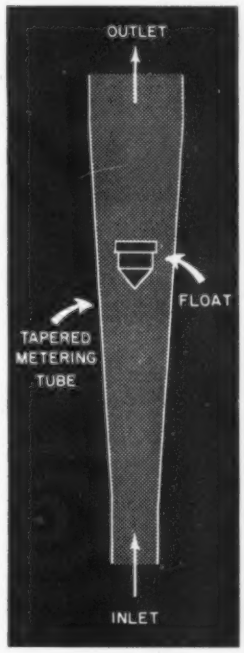
These advantages, however, must be balanced against higher cost and somewhat less flexibility in the case of the rotameter. The cost of a rotameter type pneumatic transmitter with a cast steel body is 30 to 50% greater than that of an orifice type transmitter installation for the normal ranges of pressures and flows. This cost difference increases in direct proportion to the meter size, and varies with the type of materials used in fabricating the internal parts. It must be conceded that the orifice plate is the more flexible primary element. The rotameter has greater rangeability, but the cost and difficulty involved in changing either a metering tube or float are usually greater than those of changing an orifice plate.

Used for Metering Slop Oil

Sometime ago we were faced with the problem of metering a stream of slop oil recovered from one of our separators. The quantity involved was about 300 gpm. and the material

What It Is—How It Works

THE rotameter is a flow meter of the area type which consists of a tapered metering tube mounted vertically, large end up, with a float inside. The fluid to be metered enters at the bottom and leaves at the top as shown in the figure. The area type meter is closely associated in theory with the orifice type meter, with the fundamental difference that the orifice type infers the rate of flow from the differential pressure across a constant area orifice, while the same type infers the flow rate from changes in the area of an orifice across which the differential pressure is constant. In the case of the rotameter, the annular opening between the periphery of the float and the inside wall of the tube constitutes the orifice. The area of this orifice increases as the float rises in the tube because of the taper. Thus, as the flow increases, the float moves upward increasing the area of the orifice until the differential pressure across the float just balances the weight of the float less the weight of the liquid it displaces. Since the net weight of the float is always the same, the differential pressure across it must remain constant. For any given flow rate, the float assumes a definite elevation in the metering tube, and the rate of flow may be inferred from the float position.



In practice, metering tubes may be made of glass with the flow graduations etched into the outer surface, or of metal as are those in some of the instruments described in the article. Floats may be fabricated from a great variety of materials and may take several forms depending on the character of the fluid to be measured. —T.M.H.

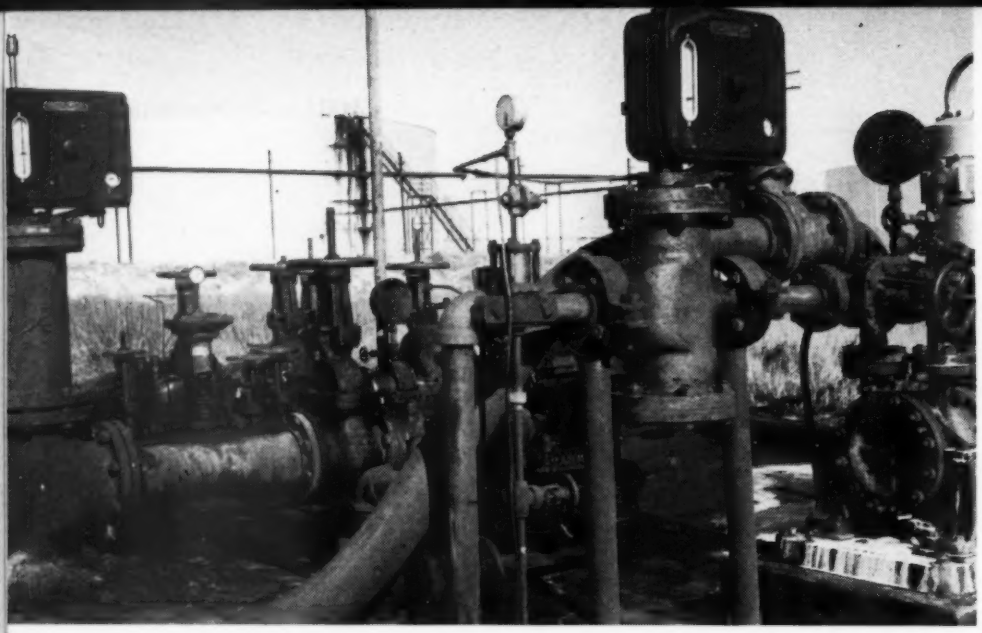


Fig. 1—Two rotameter-type pneumatic flow transmitters in a ratio control application for slop treating

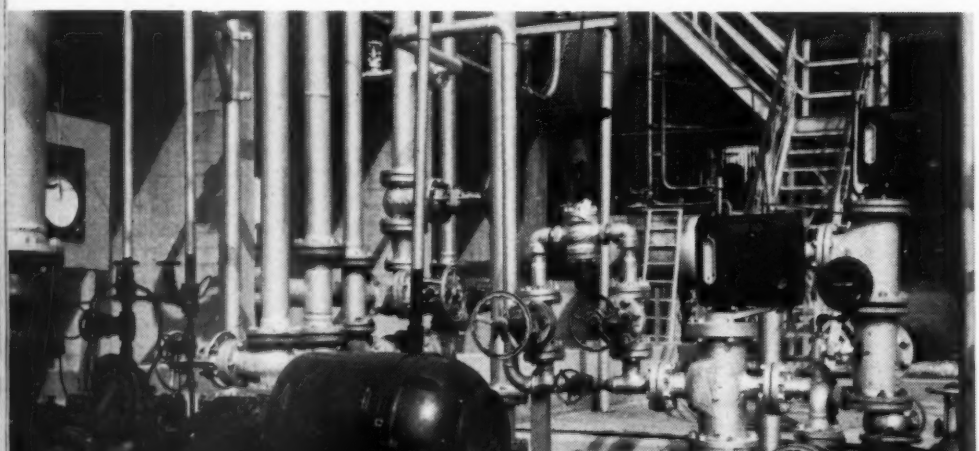


Fig. 2—Rotameter-type pneumatic flow transmitters in a ratio control application in the blending of propane and butane

Fig. 3—Two rotameter-type flow transmitters and a ratio controller in a tank farm gasoline blending application

was to be contacted with a treating agent in the ratio of 1:10. The slop contained coke particles, leaves, weeds and other debris which would plug an orifice almost immediately. Ratio control was desirable and standard differential pressure instruments with venturi tube primary elements were considered.

The location was in a tank farm in the dock area, and the operation of the system was to be intermittent with frequent opening and closing of the valves in both the slop and treating agent lines. Experience has shown that this situation is conducive to frequent loss of mercury from mercury manometer type instruments.

The rotameter type instruments shown in Fig. 1 seemed to offer the best solution. Their self-venting and non-overranging characteristics made them ideal for the type of operation contemplated. The metering tube for the slop oil instrument at the left of the photograph mounts between two 8-in. flanged tees. It has a range of 45 to 450 gpm. The 4.5 to 45 gpm. instrument for measuring the flow of treating agent is shown in the foreground. The ratio controller which controls the rate of injection of the treating agent does not appear in the photograph. Our operating and maintenance groups both report satisfaction with the performance of the system.

Automatic Blending of LP Gases

Another interesting application for a rotameter type ratio control system developed when it was decided to attempt the automatic blending of propane and butane for shipment. Again it was necessary to consider intermittent operation, but this time no solids were present to disturb measurement. The quantity involved was between 300 and 400 gpm. of butane with about 10% propane to be added. It was decided to try the rotameter type instruments in this service because their self-venting and non-overranging characteristics made them attractive for the intermittent operation. Fig. 2 shows the butane flow transmitter at the extreme right and the propane instrument in the foreground. The ratio controller appears at the extreme left of the photograph.

A third blending system in which rotameter type instruments are being employed is illustrated in Figs. 3 and 4. Here the materials are gasoline and butane, and the quantities involved are in the league of 5000 gpm. and 500 gpm. respectively. The gasoline measuring instrument shown in Fig. 4 has a range of 750-7500 gpm. and has a metering tube of such a size that it is mounted between two 20-in. flanged tees. It was found necessary in this case to go to impedance bridge type electrical transmission because of the extreme float travel.

The metering of the black sulfuric

Fig. 4—Closeup of the large rotameter-type gasoline flow transmitter used in the blending system shown in Fig. 3

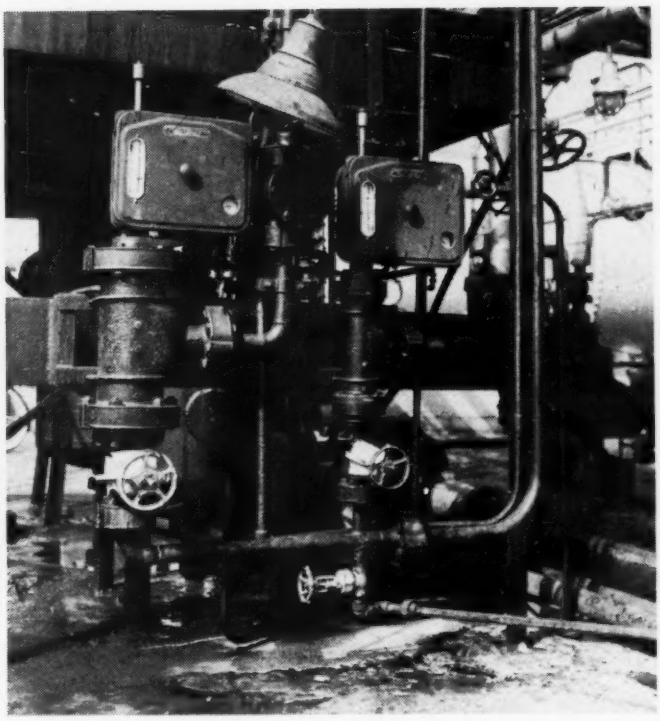


Fig. 5—Two rotameter-type pneumatic flow transmitters measuring the rate of sulfuric acid injection at a treating unit

acid used at the alkylation plant and in several treating operations in the refinery has always presented difficulties. This material is encountered in strengths between 85 and 98%. It contains carbon particles which are not only abrasive, but which have a tendency to plug most primary devices.

Originally this acid was measured with an orifice plate and an ordinary mercury-type meter equipped with liquid seals. Accuracy was poor and maintenance costs were very high. Later, a specially altered force-balance type transmitter was employed in conjunction with a flow nozzle in a down-flow meter run. This proved more satisfactory, but still left much to be desired.

Used in Acid Testers

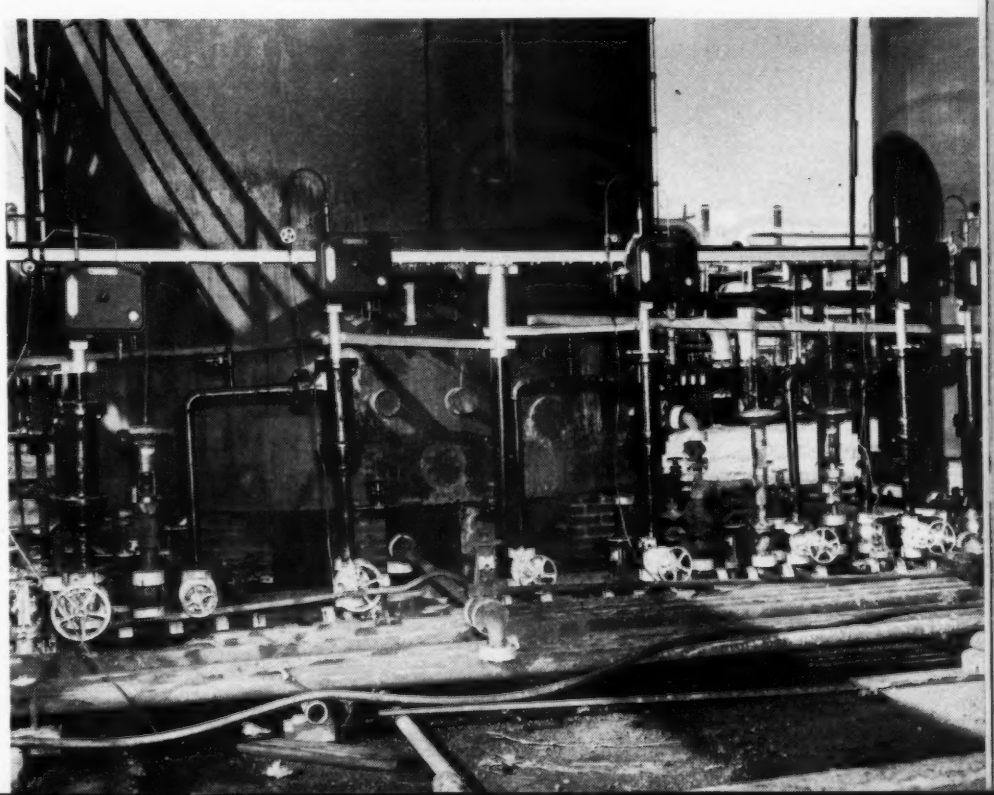
As a trial installation, the two rotameter type transmitters shown in Fig. 5 were placed in service at a treater unit. Both instruments measure the flow of 87% sulphuric acid containing carbon particles and traces of hydrocarbons. Glass metering tubes and Hastelloy floats are employed. The smaller meter has a range of 30 to 300 gph., and the large one can measure from 120 to 1200 gph. of acid. Both instruments work in conjunction with standard flow recorder controllers which control acid injection to the treater.

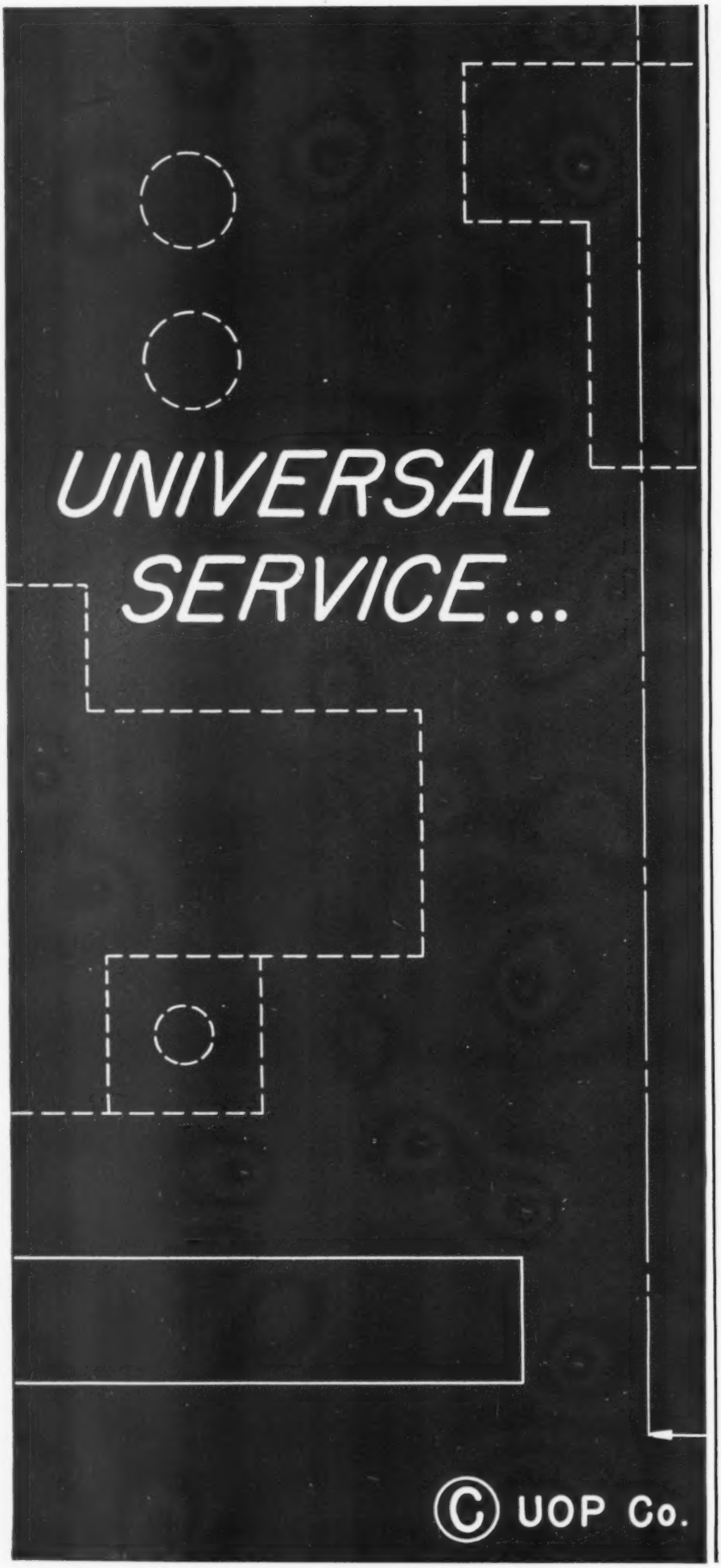
The rotameters have exhibited a higher service factor than the other types of flow meters tried in this service. Their accuracy is reported to be at least as high as that of any of the other types, and they have required very little maintenance.

On the strength of experience gained with the installation just described, seven rotameter-type flow transmitters were installed in sulfuric acid service at the alkylation plant. Some of these instruments are shown in Fig. 6. They replace the special force-balance transmitters and flow nozzles mentioned previously. In acid service, it is believed that the extra cost of the rotameter installation is small when the special meter runs and primary devices needed in conjunction with the ordinary orifice meters are considered. In any case, the added cost appears justifiable in light of the improved service factor and savings in maintenance.

In conclusion it should be pointed out that the rotameter is not a "cure-all" for flow metering problems. This type of instrument should be considered, however, where special problems such as those described occur in plant scale processing.

Fig. 6—A battery of five rotameters used for measuring acid charged to the reactors of an alkylation plant





Deep Rock Modernizes Cushing Refinery

By W. J. Carthaus

Vice President in charge of Manufacturing and Research, Deep Rock Oil Corporation

THE installation of a 5,000 barrel fluid catalytic cracking unit at our Cushing, Okla., refinery will be one of the major steps in a program of modernization and expansion which is designed principally to produce superior quality products and more efficiently. Doing this will enable us to satisfy the requirements of any internal combustion engine likely to be produced commercially for some time.

W. J. Carthaus

Deep Rock pioneered in thermal cracking in the Mid-Continent field more than a quarter century ago with one of the earliest installations of a thermal unit designed by Universal Oil Products Company. The new fluid catalytic cracking unit, which will include a gas concentration system and feed preparation facilities, is being designed by UOP.

Single Column Unit

The cat cracker will follow UOP's improved design with reactor and regenerator incorporated in a single column. It will produce catalytically cracked gasoline, domestic burner oil and cycle stock. In addition, crude facilities will be increased through the installation of a crude distillation unit.

The gas concentration system will depropanize and debutanize the catalytically cracked gasoline, and at the same time prepare feed stock for the catalytic polymerization unit. The feed preparation system for the cat cracker will consist of a combination of vis-breaking and vacuum distillation designed to give maximum flexibility.

It is interesting to note that the installation of the cat cracker will not mean the retirement of the thermal cracking plant from service, although its operation will be modified.

The present thermal cracker is a two-coil unit with rated capacity of 5,000 barrels per day. Under the new set-up the heavy oil heater will be converted to vis-breaking service as part of the cracker's feed preparation system and the light oil heater will be changed for single coil operation to crack the heavy cycle stock from the cat cracker if that should prove desirable, as well as any other available cracking stock.

To Double Poly Unit

We have at the present time, a catalytic polymerization unit which processes the gas from the thermal cracker. It

(Advertisement)

will be necessary to practically double the capacity of the poly unit, now producing about 160 barrels per day of 82 octane (Motor Method) polymer gasoline, in order to take care of the additional gas produced in the cat cracking operation. When increasing the size of this poly unit, additional provision will be made for the recovery of propane and butane from the poly plant effluent, to be marketed as LPG. The LPG facilities will utilize, in addition to two new vessels, two existing flash chambers which were formerly part of the original small thermal cracker.

Expansion of our crude capacity and the installation of the cat cracker, necessitates considerable change throughout the plant. All main transfer lines will be replaced with lines of greater capacity and 200,000 barrels of additional tankage must be constructed. To maintain a constant check on our increased operations, and to assure uniform high quality, we plan to virtually double the size of our control laboratories.

More steam is another necessity and our plans call for the installation of an additional boiler to deliver 40,000 pounds of steam per hour. We are also confronted with a great increase in our water requirements. Our boiler feed water, presently amounting to 350,000 gallons per day, will be raised to about 500,000 gallons, all drawn from the Cushing municipal system.

Complete cooperation on the part of the city has been pledged and we are assured of the additional 150,000 gallons we will need. Our process cooling water is drawn from the Cimarron River and it will be necessary to enlarge our lines and pumping facilities to handle an increased volume of water.

Enlarged Modern Office Building

Better working conditions for our refinery office staff are being provided and the existing building is being greatly enlarged and completely modernized. Plans call for the installation of the latest type of air conditioning throughout the building.

New Research Laboratory

One part of our expansion program which we consider of major importance is the construction of an air conditioned building to house a research and development laboratory. This is to be entirely independent of the control laboratory so that research men will not be diverted from their work for plant trouble shooting or to solve purely operational problems. This research and development service will be divided into four parts including research, technical service to customers, new product development and engine laboratory research on fuels and lubricants.

The Cushing refinery is located on the Great Lakes pipeline and our gasoline moves to market in that way. Many of our special products such as technical naphthas and lubricating oils, however, must be transported by rail. To facilitate the loading of such products we are replacing our present loading rack with a more efficient installation.

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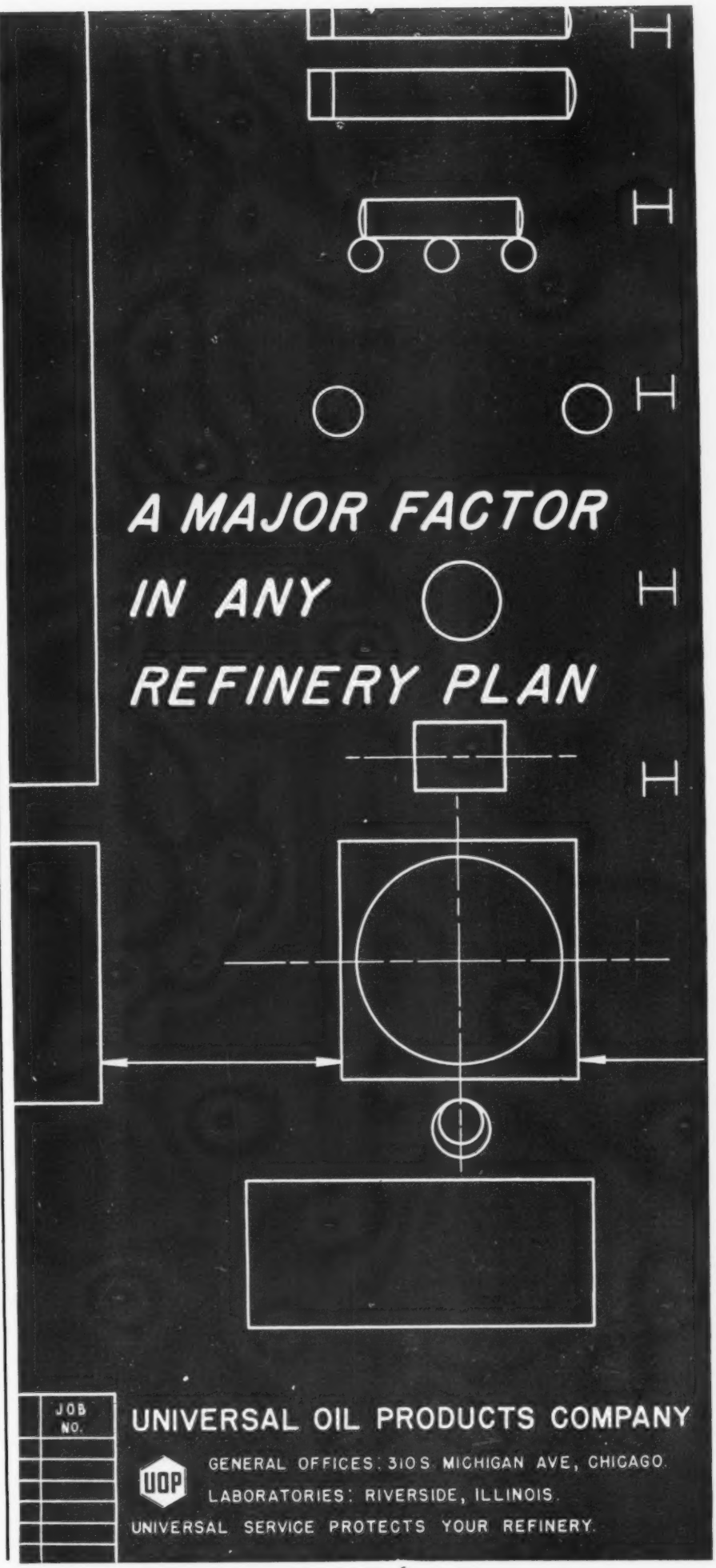


ALDEHYDES from HYDROCARBONS

By PETER W. SHERWOOD, The Koppers Co.

Two processes for the manufacture of aldehydes directly from hydrocarbons have made considerable headway in the U.S. the past three years. Partial oxidation of hydrocarbons can be made the basis of formaldehyde and acetaldehyde production. The more recent OXO process for the synthesis of aldehydes by the catalytic reaction of olefins with water gas, shows interesting potentialities for manufacture of propionaldehyde, butyraldehyde and valeraldehyde. At present, however, it is employed only as a first step in the production of iso-octyl and nonyl alcohols and other derivatives. By indirection, it can be used for the synthesis of an unlimited variety of aldehydes. Technical details of the oxidation and OXO processes are described and their possibilities and limitations briefly discussed.

IN THE FIELD OF ORGANIC CHEMICALS, the petrochemical industry has developed two important techniques for the manufacture of aldehydes from hydrocarbons. During the past three years, this work has come to fruition in the U. S. Two large plants have been constructed which are devoted primarily to the partial oxidation of hydrocarbons and one plant has been taken into operation which employs the "OXO" process for the manufacture of long-chain aldehydes. At present, these high-molecular aldehydes are still used solely as intermediates in the production of alcohols but the advent of the OXO process on the American industrial scene may well herald its future application to the end production of aldehydes, to which it is ideally suited.

Since the war, Celanese Corp. of America has erected a hydrocarbon oxidation plant at Bishop, Texas, while McCarthy Chemicals Company has built a plant at Winnie, Texas for the same purpose. At these plants formaldehyde and acetaldehyde are produced as primary products, together with methanol and other oxygenated chemicals. The technical importance of this development is that it points up the economic maturity of these oxidation processes in the U. S.

Cities Service Oil Co., as a matter of fact, built a partial oxidation plant at Tallant, Okla., as early as 1926. However, its prime purpose was to overcome a corrosion nuisance problem in the gas lines. The problem was solved by reacting all the free oxygen present in the gas and recovering the condensate formed. It was possible to pay for this operation by the sale of oxygenated chemicals contained in the product.

The OXO process which effects the synthesis of aldehydes by the catalytic reaction of olefins with water gas at elevated temperature and pressures on the other hand, is a complete newcomer to the petrochemical industry. This process can be utilized for the manufacture of aldehydes containing more than two carbon atoms. One OXO plant, at Baton Rouge, La., is already being operated by Esso Standard Oil Co.

At this plant, the final product is iso-octyl alcohol and nonyl alcohol, produced by the hydrogenation of the corresponding aldehydes. A pilot plant for the "oxoation" of diisobutylene has recently been started up by Rohm & Haas Co. at Bridesburg, Pa. Chemicals made by this plant are various derivatives of nonyl aldehyde. Other companies which show an active interest in the OXO process include Shell Chemical Co., Oronite Chemical Co., The Texas Co., and E. I. duPont de Nemours and Co.

The successful development of these two processes opens up the possible direct production of the entire field of C_1 to C_5 aldehydes from primary products of the petroleum industry. Formaldehyde and acetaldehyde can be synthesized by air oxidation processes, while the higher aldehydes—up to valeraldehyde—can be manufactured by the OXO process. By the indirect route via the alcohols, virtually every paraffinic aldehyde can today be econmoically produced from petroleum hydrocarbons.

The lower aldehydes are already among the largest-scale chemicals produced in the U. S. Formaldehyde, maufactured almost entirely by the oxidation of methanol had a 1947 production volume of 228 million pounds, an increase of 33% over the preceding year(1). Its many uses range from plastics production to the manufacture of ethylene glycol, hexamethylene tetramine, dyestuff intermediates, and a host of other applications. It is produced today by 14 different American firms.

Acetaldehyde finds important outlets in the manufacture of acetic acid, resins, chloral, etc. In 1942, U. S. production was 224,445,142 pounds(2). Since that time it has been in ever-increasing demand due to the tremendous success of the insecticide DDT, in the manufacture of which acetaldehyde figures prominently as an intermediate. As yet, almost the entire acetaldehyde supply of the nation is derived from the hydration of acetylene and from the oxidation of ethanol.

Classical methods for the manufacture of higher aldehydes are generally quite costly. The most important processes involve the oxidation of primary alcohols and the condensation of a suitable number of acetaldehyde molecules followed by partial hydrogenation of the product. Thus, butyraldehyde can be produced by the oxidation of n-butanol or by the condensation of two acetaldehyde molecules to form crotonaldehyde, $CH_3 - CH = CH - CHO$, which upon partial hydrogenation yields n-butyraldehyde. These products already exceed the range of "cheap" chemicals. Butyraldehyde is today quoted at 20c/lb. while acetaldehyde is available at approximately half this price. The high price has discouraged the development of an adequate market for the higher aldehydes and it is here that the petrochemical industry will tread on almost virgin ground.

The problem becomes more serious as the molecular weight of the aldehydes increases. The cost of synthesizing these materials by condensation of lower aldehydes eventually becomes prohibitive. On the other hand, there is no classical method for the economical production of the higher primary alcohols. N-butanol can still be manufactured at reasonable cost by fermentation methods. This approach fails, however, for the higher alcohols. At the same time, no solution is found in the hydration of olefins. This process results in the almost exclusive production of secon-

dary and tertiary alcohols. Upon oxidation, secondary alcohols will, of course, produce ketones, while tertiary carbinols can only be oxidized destructively. It is for the solution of this problem that the petrochemical industries have now forged the powerful tools of the partial oxidation and OXO processes.

ALDEHYDES BY OXIDATION OF HYDROCARBONS

The study of combustion gases from hydrocarbons had made it evident at an early date that the lower aldehydes are formed in the course of the burning process. Under the drastic conditions of the flame, the aldehydes are not stable, however, and all but a trace of formaldehyde and acetaldehyde is decomposed to oxides of carbon and water.

Willstaetter and Bomer[3] and Blair and Wheeler[4] made a classical study of conditions favorable to the thermal oxidation of hydrocarbons to useful organic products. These authors found that the oxidation of ethylene is still very slow at 350° C., the temperature at which ethylene begins to be unstable. At the same time, the main useful reaction product—formaldehyde—is unstable at temperatures above 310° C. It is therefore necessary to operate with low concentrations of both ethylene and formaldehyde and to permit only little conversion per pass, keeping the time of heating at a minimum. By extreme observance of these requirements, Blair and Wheeler were able to obtain a 75% of theory yield of formaldehyde by the oxidation of ethylene at 575° C. It was necessary, however, to recycle the gases so many times and to maintain conversion per pass at such a low level that the process had only academic interest.

In the case of methane, which is thermally much more stable, it was not necessary to dilute the hydrocarbon. By maintaining an oxygen deficiency and again taking a very low conversion per pass and short heating time, it was possible to oxidize methane to formaldehyde with 65.5% yield at 720° C.

In general, lower temperatures can be successfully employed for the partial oxidation of higher hydrocarbons than for the lower members of the family. This observation has been made the basis of a process of the Celanese Corp. for the manufacture of the lower aldehydes and alcohols by the partial oxidation of butane[5].

The necessity for carrying out thermal oxidation at temperatures at which aldehydes are not stable, has led to the development of catalytic oxidation processes. The first patent for the catalytic oxidation of methane for formaldehyde is due to G. Glock[6] who recommends the use of a copper catalyst. Since 1898, the date of issuance of the Glock patent, a host of other patents has recommended almost every conceivable metal and metal oxide as oxidation catalyst. A partial list of the recommended catalysts includes uranium, silver, nickel, molybdenum, vanadium, barium oxide and peroxide, etc.

Good preferential production of aldehydes by hydrocarbon oxidation has been achieved by the use of gas phase catalysts. The tested catalysts include HCl, HBr, ozone, SO_3 and a host of others. Particularly good results have been reported for the use of nitrogen oxides as catalysts. By the addition of small amounts of nitrogen oxides to a mixture of hydrocarbons and air, Bibb and Lucas[7] were able to obtain formaldehyde with a conversion of 4% per pass. Sheely and King[8] oxidized a naphtha fraction with air in the presence of a nitrogen oxide catalyst and obtained a yield of 19.7% aldehydes and 25.4% carboxylic acids.

The stabilizing effect of steam on the products of oxidation has been demonstrated by R. Schonfelder[9], who was able to convert methane to formaldehyde with 56% yield by air oxidation in the presence of steam over a copper catalyst at 500° C.

The modifying influence of steam on the partial oxidation of hydrocarbons is one essential element in an important patent by J. E. Bludworth[5]. This patent is concerned with the thermal oxidation of butane in the presence of large amounts of steam to yield formaldehyde, acetaldehyde, methanol and organic acids. One example cites the reaction of one volume butane with ten volumes air in the presence of 110 volumes steam. The reaction is carried out between 300 and 400° C. at a pressure of 300 to 400 psi. After one second in the reaction zone, the product is immediately quenched and water-soluble materials are scrubbed out of the effluent gases. One hundred lbs. butane are stated to yield 15.2 lbs. formaldehyde, 19.6 lbs. acetaldehyde, 7 lbs. acetone, 19 lbs. methanol, 1 lb. propanol, .5 lb. butanol, and 11.4 lbs organic acids.

This Bludworth patent is reported to be fundamental to the operation of the new plant of the Celanese Corp. at Bishop, Texas, which was built at cost of $20,000,000 in 1945-6[2].

In the partial oxidation plant of Cities Service Oil Co. at Tallant, J. C. Walker and associates developed a process for the complete reaction of all the oxygen present at elevated temperatures and pressures[10]. As originally practiced, the process involved apparently a thermal oxidation although it has recently been stated that an aluminum phosphate catalyst is employed[11]. The liquid product of the plant contains 20% formaldehyde and 5% acetaldehyde. The remainder is mainly methanol, acetone, dimethyl acetal, higher alcohols, and water.

Information has been published on a formaldehyde plant constructed in Roumania by Gute Hoffnungshütte, a German firm[12]. This plant employs the low pressure, high temperature partial oxidation of methane with air in the presence of a small quantity of nitrogen oxide catalyst. The feed gas to the reactors is made up of one volume methane, 3.7 volumes air and 42 volumes recycle gas. A volume of nitric oxide equal to 0.08% of the fresh gas volume is added to the process gases which have been heated to 400° C. The reaction itself is carried out in an empty re-

Meet the Author

Peter W. Sherwood has been with Koppers Co., Inc., since early 1943, one year being spent on a Koppers Fellowship at Mellon Institute of Industrial Research. A process design engineer, he is concerned with the technical and economic evaluation of various chemical processes and the design and estimating of chemical and fuels plants.

In 1945-46, with the Technical Oil Mission to Germany, he spent over a year as Assistant Chief of the Fuels and Lubricants Unit of Field Information Agency, Technical, investigating German war-time industrial developments. He studied German synthetic oil, petroleum and petrochemical technology and has recently published "High Pressure Hydrogenation in Germany", a monograph on German coal liquefaction technology.

Mr. Sherwood received his undergraduate training and his M.S. in chemical engineering from Columbia University and has continued his graduate studies at Brooklyn Polytechnic Institute and at the University of Pittsburgh.

action chamber at 400 to 600° C. The exit gases from the reactor are scrubbed with water to yield a product containing 34 wt.-% formaldehyde, 3% methanol, and 63% water. A 35% yield of formaldehyde was obtained.

The use of ozonized air for the partial oxidation of hydrocarbons is claimed to give good yields of formaldehyde. C. B. Carter and A. E. Coxe[13] have process for the conversion of ethylene by ozonized air. A 70% yield of formaldehyde and 15% yield of formic acid is claimed. More recent work by Schmitt and Rintorff [12] [14] indicates that methane can be oxidized in 90% yield in a single-pass operation, using ozonized oxygen or air over a catalyst consisting of barium peroxide and silver oxide promoter on a porcelain carrier. The reaction is carried out at 100-120° C. The oxidation of ethane under similar conditions is claimed to give good yields of acetaldehyde, while the oxidation of propane is said to be the basis for propionaldehyde production.

In general, partial oxidation processes of methane and ethane at normal pressures yield predominantly formaldehyde, while elevated pressures tend to result in the formation of large amounts of alcohols. Propane, butane, and pentane can be oxidized successfully to a primary yield of acetaldehyde, with the formation of smaller amounts of formaldehyde. Here again, the effect of pressure is to increase the production of alcohols.

SYNTHESIS OF ALDEHYDES BY THE OXO PROCESS

The second important process for the large-scale synthesis of aldehydes from hydrocarbons is a comparative newcomer to the industry. The first suggestion of this reaction was published by Smith, Hawk, and Golden[15] in 1930. These authors noted the formation of large amounts of oxygenated compounds when ethylene, carbon monoxide and hydrogen were passed simultaneously over a cobalt catalyst at elevated temperature and pressure.

It was, however, not until 1939 that a thorough study was made of the nature of these products by O. Roelen and associates. U. S. 2,327,066[16], issued in 1943, is probably the first public announcement of the OXO reaction for the synthesis of alcohols and aldehydes from olefins and water gas:

$$R - CH = CH_2 + H_2 + CO \rightarrow RCH_2 - CH_2(CHO)$$

or $R - CH(CHO) - CH_3$ .... (1)

The OXO reaction is almost universal. It can, in effect, be employed with all mono-olefins, ranging from ethylene to pinene. In each case, straight-chain and α-methyl aldehydes are formed. The proportion of these products depends on the amount of steric hindrance encountered. Thus, isobutylene will yield more $CH_3 - CH(CH_3) - CH_2 - CHO$ than $CH_3 - C(CH_3)_2 - CHO$. In the "oxoation" of the simpler olefins, it may be stated as a rough rule that the aldehydic product is 60% branched-chain and 40% straight-chain.

The conditions of the reactions are comparatively mild. Depending on the nature of the olefin to be oxoated, the reaction temperature is between 110 and 150° C. The reaction is preferably carried out at elevated pressures ranging near 200 atm. and in the presence of small amounts of cobalt catalyst. The catalyst is usually in the form of a slurry, but information also has become available on partially successful attempts to carry out the reaction over a fixed catalyst bed. A yield of about 90% aldehyde is obtained.

ONLY LOWER ALDEHYDES RECOVERABLE IN PURE FORM

In addition to the two main products indicated by Equation (1), the higher olefins are oxoated to form the entire gamut of isomeric aldehydes. This is mainly due to the strongly isomerizing action which cobalt carbonyl exerts on the double bond under the conditions of the OXO reaction. Thus, it has been shown[17] that octene-1 is converted to its—2, 3, and 4 isomers in the presence of a cobalt catalyst and carbon monoxide at 200 atm. and only 150° C. At this low temperature, essentially no isomerization was effected when nitrogen was substituted for carbon monoxide. Under the conditions of the OXO reaction, this double-bond isomerization is of secondary importance, however, because the rate of oxoation greatly exceeds the rate of isomerization.

As a result of this complexity of reactions, the product of the OXO reaction, while 90% aldehydic, is still a complex mixture of isomeric aldehydes. In order to minimize the problem of purification, it is universally necessary to start with a pure olefinic stock. In spite of this precaution, the end product must be thoroughly fractionated. However, aldehydes above C_5 would have to be subjected to such drastic conditions of distillation that large amounts of the reactive aldehydes are converted to esters (by disproportionation), aldols (by condensation), and other undesired products. The yield of aldehydes eventually becomes so low that recovery by this method becomes prohibitive.

Most of the important work done to date with the OXO reaction has therefore been toward the immediate production of alcohols by the hydrogenation of the unpurified aldehydes. The alcohols, being thermally and chemically much more stable than aldehydes, properly can be purified and the pure alcohol can be reconverted to the corresponding aldehyde by a mild oxidation.

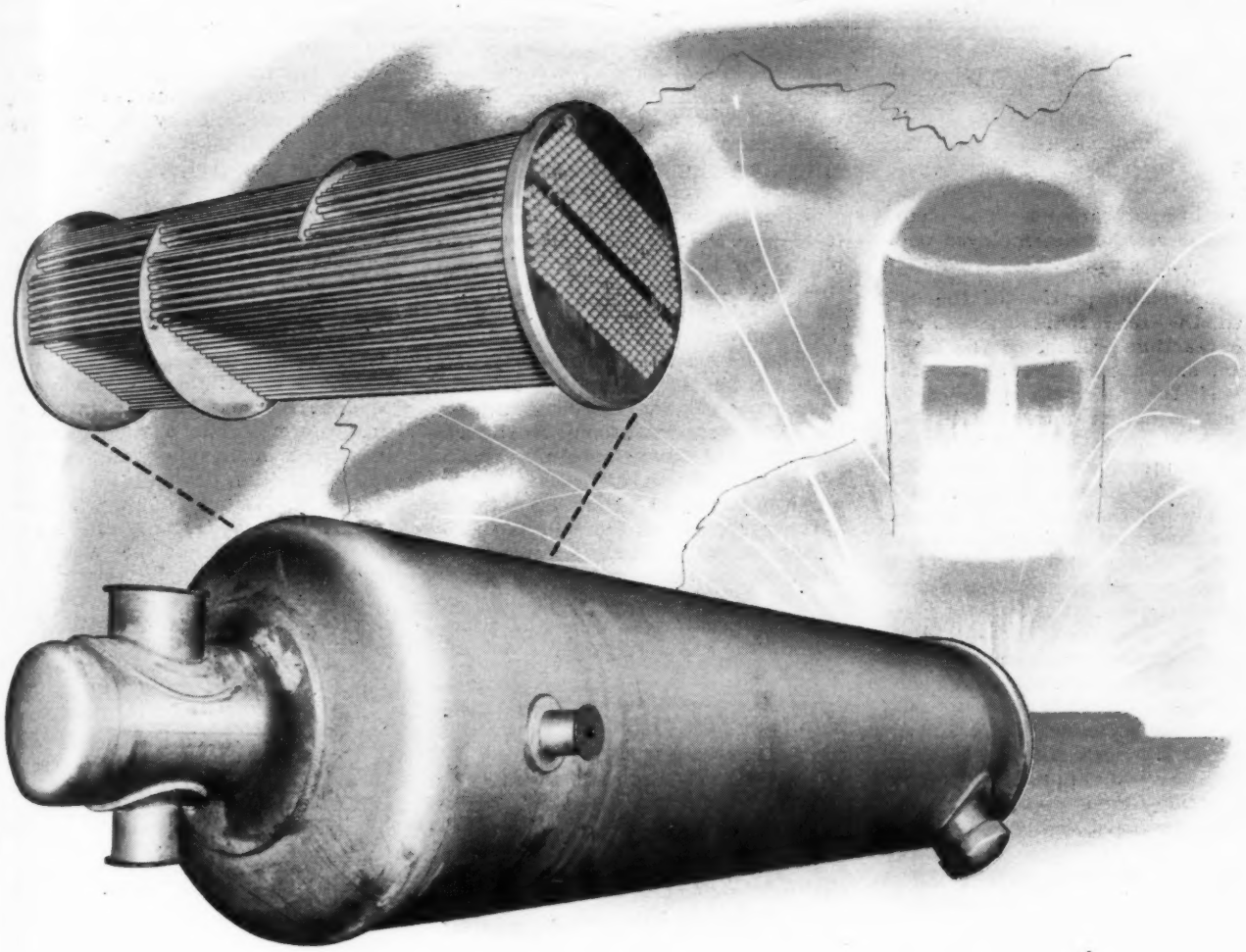
These statements apply to a lesser extent to the low-boiling aldehydes. The lowest aldehyde which can be produced by the OXO reaction is, of course, propionaldehyde, synthesized from ethylene and water gas. In this case, only one isomeric aldehyde is possible, and the product has a low boiling point. It is, therefore, possible to recover propionaldehyde from the reaction mixture by simple distillation. A propionaldehyde plant has been designed by I. G. Farbenindustrie for use at Colleferro near Rome, Italy. This plant will be discussed below in greater detail.

Butyraldehyde is capable of the formation of only two isomers which can be purified and recovered in good yield. The same is true of valeraldehyde, although in this last case the formation of undesirable byproducts becomes already appreciable. Aldehydes formed by the OXO reaction with pentene or higher olefins are subject to the limitations of recovery which have been outlined above. By present processing methods, it is doubtful whether these higher aldehydes can be successfully synthesized in pure form by the OXO reaction. Here, the main importance of oxoation rests in the manufacture of aldehyde mixtures, either for direct sales—if outlets can be developed—or as an intermediate in the production of the corresponding alcohols. The alcohols can be readily purified and employed either for the manufacture of detergents or for reoxidation to the desired pure high-molecular aldehyde.

COBALT CATALYSTS USED IN THE OXO PROCESS

The OXO reaction has been successfully carried out in the presence of both cobalt and iron catalysts of the Fischer-Tropsch type. Most of the reported work carried out at Ruhrchemie, A. G. and by I. G. Farbenindustrie at Merseburg and at Ludwigshafen, was based on the use of the standard Fischer-Tropsch cobalt catalyst, containing 30% cobalt, 2% thoria, 2% magnesia, and 66% kieselguhr. This catalyst was presumably employed preferentially because it is a highly active form of cobalt which was available at German Fischer-Tropsch plants.

It has been shown, however, that the active principle of the catalyst is cobalt carbonyl which is formed under the conditions of the OXO reaction. In the process version of Ruhrchemie, the cobalt catalyst was added in the form of a slurry and was carried as such through the re-



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action stage, after which most of it was filtered off. In the course of the reaction, cobalt carbonyl is developed some of which leaves with the effluent gases. Most of this cobalt carbonyl can be recovered by scrubbing with hydrocarbons. The olefin feed to the reaction is employed usefully for this purpose.

An appreciable portion of the cobalt in the feed remains dissolved in the reaction product of the OXO reaction and passes through the filters. If the aldehydic product is used solely as an intermediate for alcohol production, no special treatment is required. Cobalt is quite insoluble in the product alcohols and settles out in the course of hydrogenation, ready to be filtered and reused. If, on the other hand, aldehydes are desired as the final product, special treatment is necessary to remove the dissolved cobalt. Not only is the cost of cobalt appreciable, but the mixture of cobalt and aldehydes is also very susceptible to oxidation. The introduction of small amounts of air into such a system results in very appreciable yield losses, while larger amounts of air may actually cause spontaneous ignition.

In the production of higher aldehydes, it is possible to remove the cobalt from solution by treating the aldehyde mixture with 5% sulfuric acid solution at 40° C., in the absence of air. This treatment is not possible for the lower aldehydes because it would promote the formation of appreciable quantities of aldols. At the same time, sulfuric acid treatment is generally not necessary for the lower aldehydes which can be removed from the product mixture by direct distillation. The cobalt carbonyl in the still residues is precipitated as metallic cobalt and can be recycled to the OXO reaction stage.

The slurry-type of operation has the distinct disadvantage of requiring a laborious mixing procedure and an equally cumbersome filtration step. Attempts were made at Ludwigshafen to use a fixed-bed catalyst. A special copper chromite catalyst on pumice was found to give good yields and to have lower carbonyl losses than the normal Fischer-Tropsch cobalt catalyst[18]. Another fixed-bed catalyst with low carbonyl losses was developed at Leuna from cobalt alloys. None of these catalysts had very good physical strength, however, and space-time yields were considerably below those obtained by the slurry process.

None of the fixed-bed OXO processes were therefore ever considered to be economically competitive with the slurry-type process. An interesting approach to the fixed-bed studies at Ludwigshafen was the replenishment of cobalt which had been removed in the form of volatile carbonyl by the addition of soluble cobalt stearate to the olefin feed[19]. This lengthened the life of the fixed-bed catalyst appreciably but did not extend it beyond about four weeks.

Sulfur, which is known to be a fatal poison for cobalt catalyst employed for the Fischer-Tropsch reaction, does not destroy its usefulness for the OXO reaction. On the other hand, sulfur does destroy the ability of cobalt to act as an efficient catalyst for the hydrogenation of aldehydes to alcohols. In the course of the OXO reaction, some of the aldehydes are immediately reduced. Where aldehydes are the desired end product, it has therefore been found advantageous to add small quantities of organic sulfur to the feed[20]. The effect of this addition is the destruction of the hydrogenation ability of the cobalt catalyst while the progress of the OXO reaction is not affected.

REACTION CONDITIONS OF THE OXO PROCESS

The OXO reaction is always carried out in the liquid phase. Where the raw materials are gaseous olefins, it is necessary to employ an auxiliary solvent. Usually an inert hydrocarbon is selected which differs in its boiling point sufficiently from the resulting aldehyde to permit ready separation by fractionation. In laboratory work, cetane has been used to advantage. The Bombrini propionaldehyde plant at Colleferro was designed for the use of toluene as solvent.

The reaction temperature depends on the olefin employed. The low-molecular weight olefins are generally reacted at somewhat higher temperatures than are the higher olefins. The OXO reaction proceeds in better yields at the higher temperature while the danger of double-bond isomerization does not exist for the gaseous olefins. The lower olefins give yields of only about 75-80% while the higher olefins can be converted to aldehydes with 90% efficiency. Propylene in cetane can be oxoated at temperatures above 80° C. However, a satisfactory reaction rate cannot be obtained below 95 to 110° C.[21]. The OXO reaction with olefins which are normally liquid can be effected at temperatures as low as 45 to 65° C., but is also preferentially carried out above 100° C. in order to obtain a better reaction rate.

In the oxoation of the higher olefins, it is desirable to operate at the lowest practicable temperature because the tendency toward double-bond isomerization is more pronounced at elevated temperatures while the OXO reaction is not markedly affected by raising the temperature above a certain minimum. The usual operating range is 115-190° C. It is influenced to a certain extent by the age and quality of the cobalt catalyst and must be increased as the same catalyst is reused several times.

To effect an adequate partial pressure of water gas, it is necessary to operate at elevated pressures, usually in the range of 100-200 atm. The water gas composition is generally equal volume parts of carbon monoxide and hydrogen, i.e., the theoretical ratio. Higher hydrogen ratios tend to increase the amount of hydrogenation, while a water gas rich in carbon monoxide favors isomerization of the double-bond position. Within the vicinity of the 1:1 carbon monoxide to hydrogen ratio, the exact composition of the water gas does not appear to be very critical.

The extent and rate of the OXO reaction is greatly dependent on the pressure. The following extent of effective conversion has been reported[20] for laboratory operation. Reaction time was 1 hour.

Pressure (atm.)	Approximate Conversion (%)
50	10
100	50
150	70-80
225	95

The degree of intimacy of contact between water gas and the liquid phase determines the normal reaction time. In batch systems, proper mechanical agitation must be provided, while in continuous systems the necessary contact can be achieved by proper design of the reactor to accomplish intimate mixing by the flow characteristics of the reactants.

THE MANUFACTURE OF PROPIONALDEHYDE

Ethylene, propylene, and butene are the olefins which lend themselves most readily for the direct production of aldehydes by the OXO process. The direct synthesis of the higher aldehydes is defeated by difficulties which are encountered in the course of the recovery and which have been outlined above. Their manufacture will have to take the indirect route of oxoation, reduction to alcohol, fractionation and reoxidation of the purified alcohol.

Typical of the operation of an OXO plant is the propionaldehyde plant designed by I. G. Farbenindustrie for Bombrini - Parodi - Delfino which was to be constructed at Colleferro, Italy. This plant never went into actual operation. However, its design, based on pilot-plant and semi-commercial operation at Ludwigshafen and Holten, is of considerable interest because it summarizes German experience on the oxoation of olefins for the production of pure aldehydes.

The design capacity of the Bom-

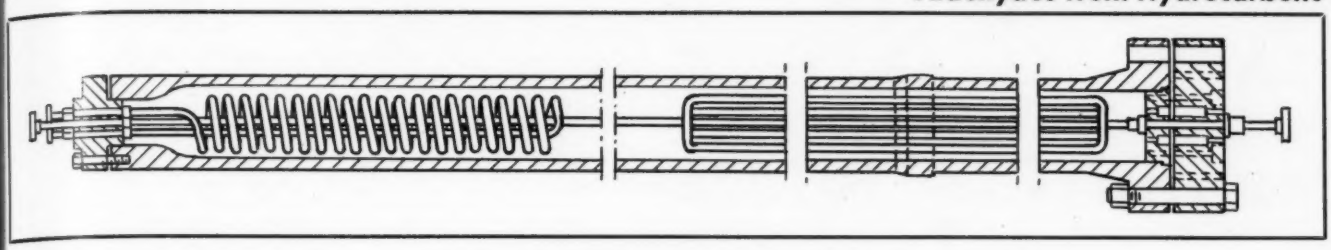

Fig. 1—Converter for OXO reaction

brini plant was 25 to 30 metric tons of aldehyde per month. The reaction was carried out in a high-pressure reactor shown in Fig. 1. Cooling coils must be provided to remove the very appreciable exothermic heat generated in the course of the OXO reaction. About 100 Btu must be removed for every pound of propionaldehyde formed.

Fig. 2 is a flow sheet of the Bombrini plant. Ethylene, water gas and recycle gas enter the bottom of the reactor, while the cobalt catalyst dispersed through toluene, which is used as solvent in this particular plant, enters counter-currently near the top of the reactor. The gases leaving the reactor are cooled and scrubbed for aldehyde recovery. The gas is then recycled after having been fortified with makeup water gas. The bottoms of the reactor are cooled and filtered. The propionaldehyde is distilled out from the product mixture. The bottoms are recycled to the reactor and the cobalt catalyst is reused without regeneration. The heavy products formed in the course of the reaction were expected to serve as solvent, obviating the necessity for outside replacement of toluene losses. The catalyst must be replaced periodically. Only about 50 grams of catalyst are required per kilogram of working liquid. Operation at 90-100° and 150 atm. was proposed. Yields of about 60-70% were expected.

Operation in an aqueous phase at 200° C. and 200 atm. was also considered and is reported to have a definitely favorable effect on the propionaldehyde yield which was stated to have reached values as high as 90% in pilot plant experiments. At the same time heat could be removed by the evaporation of water. It is believed that solution of propionaldehyde in the H_2O phase prevents aldol condensation to a great extent. In this latter case, the presence of water in the system has the main disadvantage of requiring the recovery of the aldehyde from a very dilute aqueous solution. When it is desired to produce higher aldehydes, the presence of water—often formed in the course of reaction—introduces great difficulties in the purification step because of the formation of a variety of azeotropes.

The Bombrini plant for the manufacture of propionaldehyde has been described in considerable detail by Holm, Nagel, Reichl, and Vaughan(19).

ECONOMICS OF PROCESSES FOR PRODUCING ALHEHYDES

At present, the processes of hydrocarbon oxidation and olefin oxoation offer a definitely favorable picture for the production of the lower aldehydes. Formaldehyde and acetaldehyde, along with some other oxygenated petroleum derivatives, are already being produced on a large scale in the U. S. The OXO process offers a ready method for the large-scale production of propionaldehyde, butyraldehyde and the isomeric valeraldehydes from readily available and comparatively inexpensive raw materials. Indirectly a

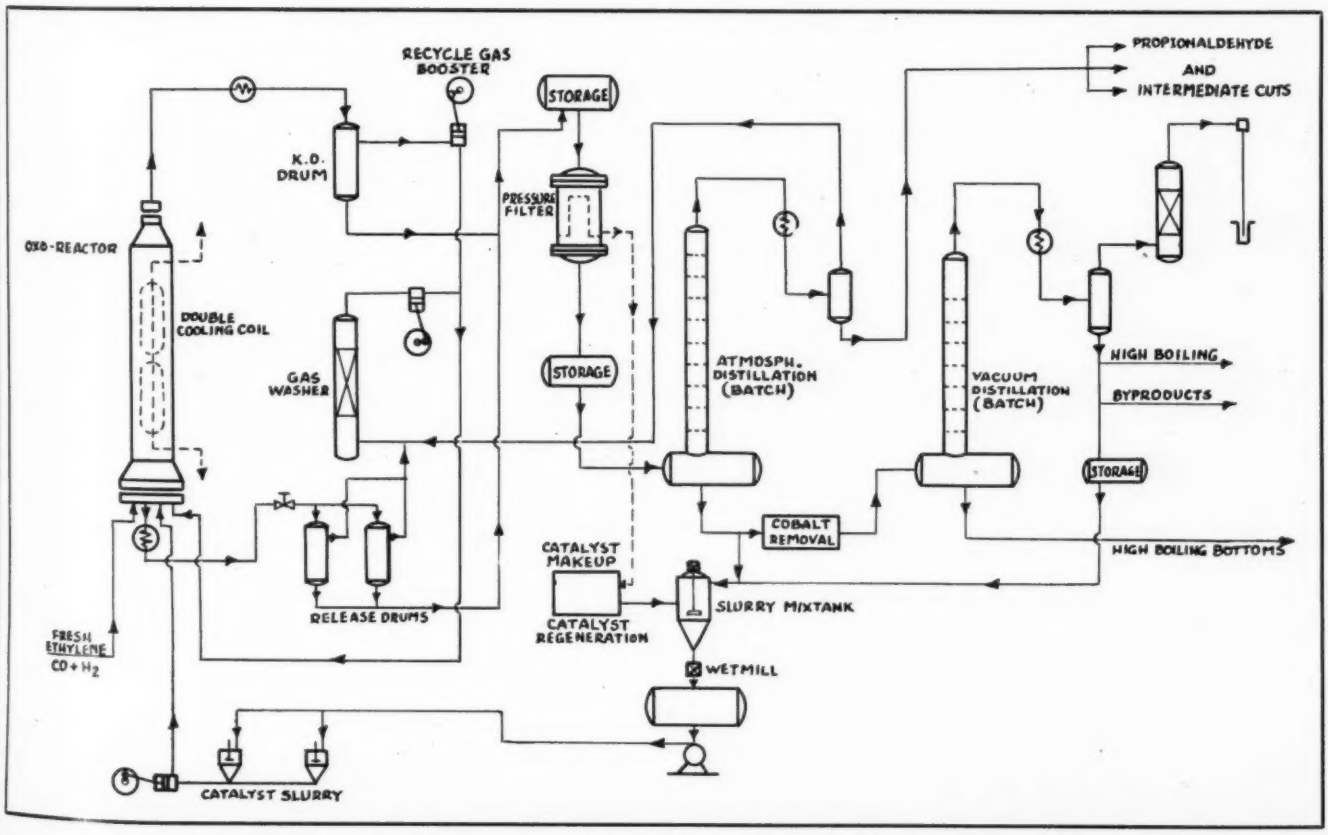

Fig. 2—Flow sheet for the manufacture of propionaldehyde (Bombrini process)

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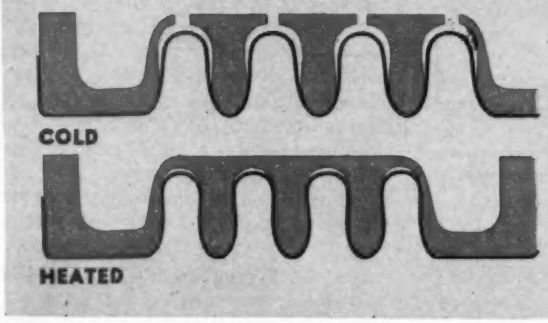

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method is also given for manufacturing n-propyl alcohol and other higher alcohols by inexpensive methods. At this time the market is not ready to absorb the large quantities of the C_3, C_4, and C_5 aldehydes now potentially available, but large-scale outlets may be developed.

The higher aldehydes probably cannot be produced cheaply in pure form directly from hydrocarbons. A devious route must be selected in which a mixture of OXO aldehydes is hydrogenated to the corresponding alcohols which can be separated and reoxidized to the pure aldehydes. Mixtures of long-chain aldehydes are beginning to play an important part as intermediates in the manufacture of long-chain alcohols which, upon sulfonation, yield valuable detergents.

It is difficult to say at the present time how the advent of the Fischer-Tropsch process on the American industrial scene will affect the market and economics of the petrochemical aldehydes, or, for that matter, of any low-molecular oxygenated petrochemical other than formaldehyde. Huge amounts of acetaldehyde, propionaldehyde, and butyraldehyde have been reported as potential byproducts.

At the same time, tremendous amounts of C_1 to C_4 alcohols are expected. It is not, at this time, clearly shown that the cost of the Fischer-Tropsch byproduct chemicals will be below those of currently extant petrochemicals. The time is therefore not yet ripe for speculation on the effect of an economically uncertain process.

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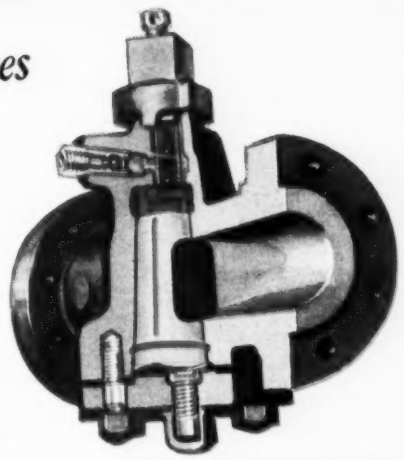

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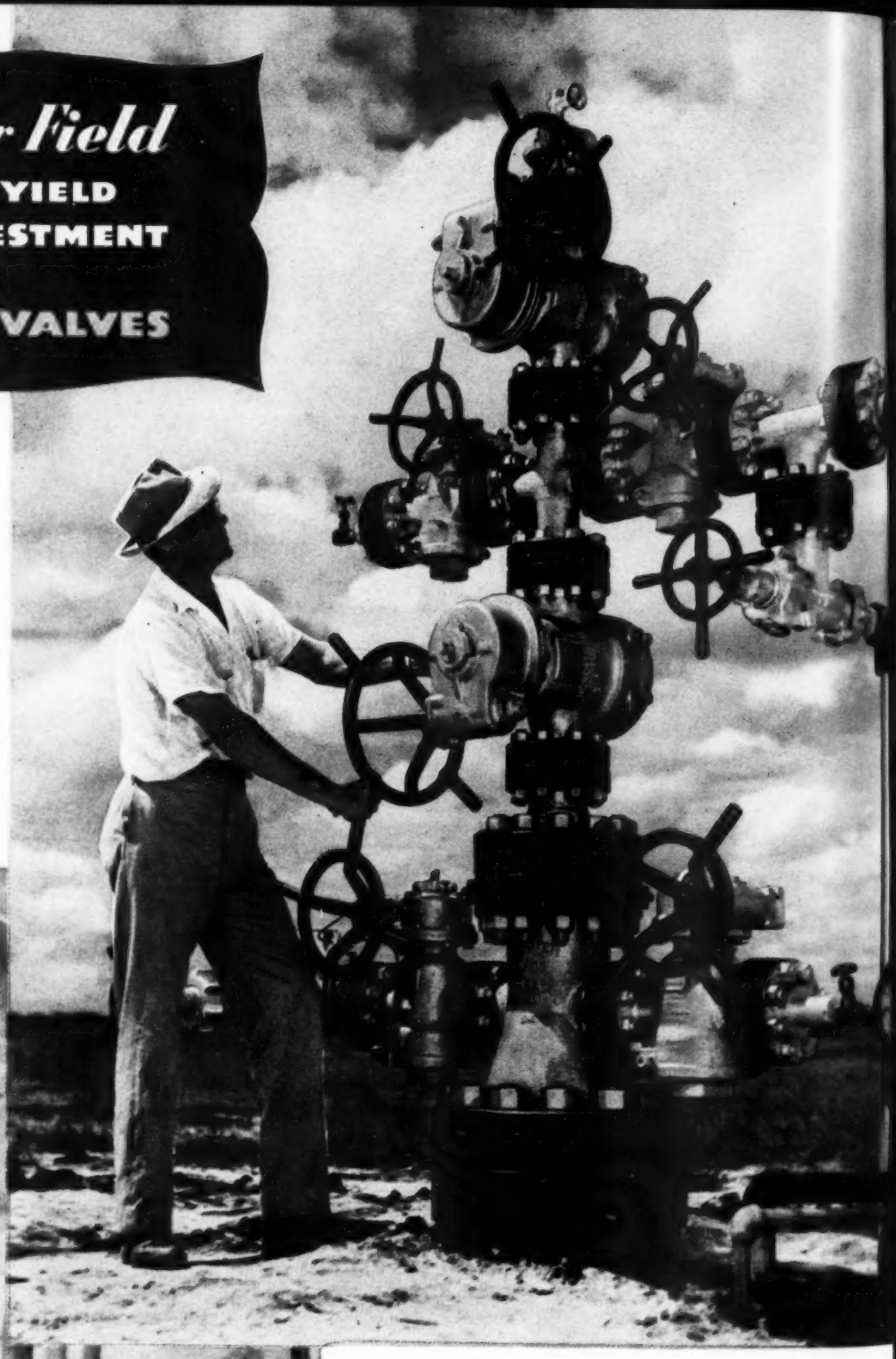

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Plant Practices

Practical Tips and Ideas for Improving Operations

Conveyor Crosswalks Improve Safety For Packaging Department Employes

THE packaging department in the Philadelphia refinery of Gulf Oil Corp. makes considerable use of roller conveyors to move filled drums of oil, grease, and other packaged products from filling machines and scales to interim storage or to the shipping docks.

Workmen must cross these various roller conveyor lines to reach certain points in the department. Because of the width of the conveyor—about 2½ ft.—and its height above the floor, the workmen must either step on the rollers or all the way across. Either practice constitutes a potential tripping, or slipping, and falling hazard. To provide safety, a simple passageway was built across the conveyors which provides solid footing yet does not interfere with the normal functioning of the rollers. It is illustrated in Fig. 1 and in the photograph.

It comprises a set of T-bars welded across from each side member and located between each roller so that the top of the T-bar is 1/16 in. below the top of the roller. Thus the T-bar assures an employe of firm footing but does not prevent a drum from rolling freely along the conveyor.

The dimensions given in the drawing are for a conveyor using 2¼-in. diameter rollers mounted on 4-in. centers between a 4-in. channel and a 2½ x 2 x ¼-in. angle iron. The T-bars have been cut from 4-in. I-beam as indicated, and their flange edges have been beveled to suit the arc of the rollers. The 1/16-in. clearance between the roller top and the T-bar top must be held for the full width of the conveyor. The same design but with different T-bar sections is utilized for conveyors with other size rollers and spacings.

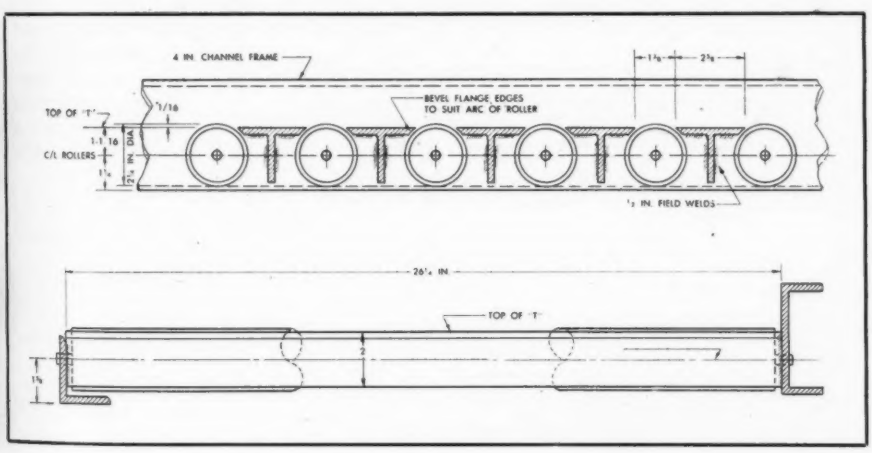

Fig. 1—Safe crosswalk on roller conveyors in Gulf's packaging department at Philadelphia refinery. Above, typical section through rollers: below: typical section through frame

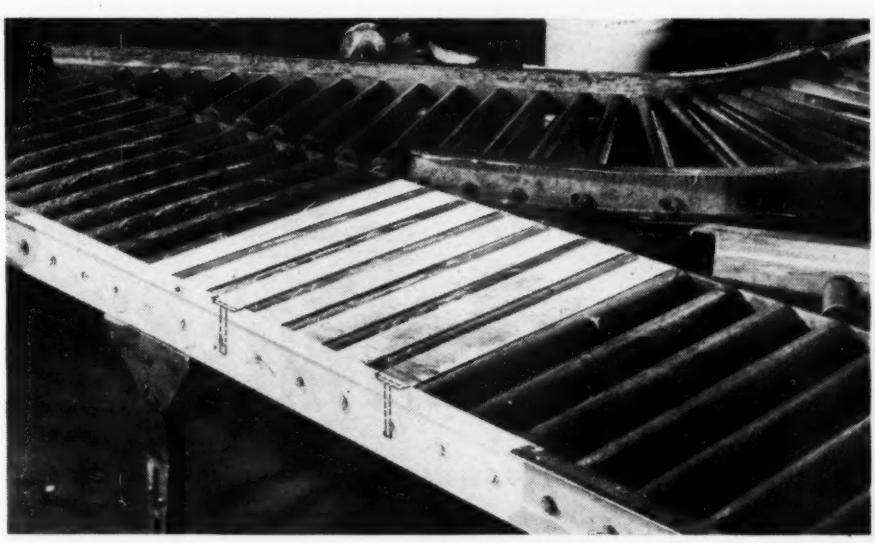

Photo shows installation of a safe crosswalk. Dotted lines were drawn in to indicate use of T-bars

Pipe in Service Can Be Cut With Saw and Valve Device

CONNECTIONS can be made to pipe carrying liquids without taking the piping out of service through the use of a device worked out by the maintenance department at the Catlettsburg, Ky., refinery of Ashland Oil & Refining Co. It is illustrated in the simplified drawing in Fig. 2.

An assembly comprising two flanged nipples and a gate valve, as shown, is welded to the pipe which is to be tapped and at the proper location. The top fitting in the assembly includes a bearing for the drive shaft of a rotary saw of the desired size for the hole to be cut. The gate valve is left open until the cut has been made. Then the saw is withdrawn into the upper nipple and the gate valve is closed.

The result is a side-entering connection, complete with gate valve and ready for use. In actual practice the saw is only slightly smaller

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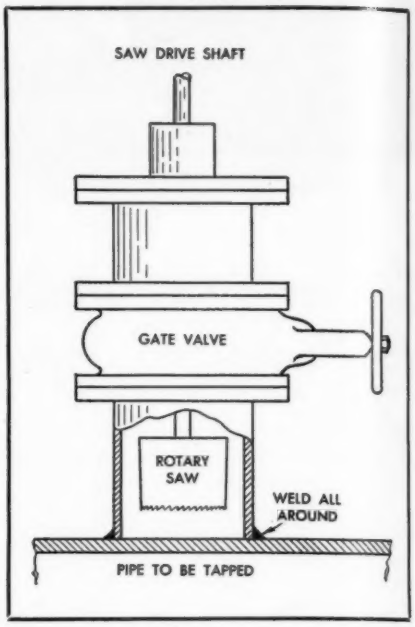

Fig. 2—Ashland's device for making side connections to piping while it is still in service

than the inside diameter of the connecting nipple. The proportions in the sketch were exaggerated to show details. A taper in the saw enables it to pull the cut-out along when the shaft is pulled up.

Connections of almost any desired pipe diameter can be made simply by changes in the size of the rotary saw, or trepan. The saw can be driven by any convenient means at hand, a portable air motor or an electric power tool.

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Ordinary Refrigerator Collects Samples For Bacteria Tests on Refinery Wastes

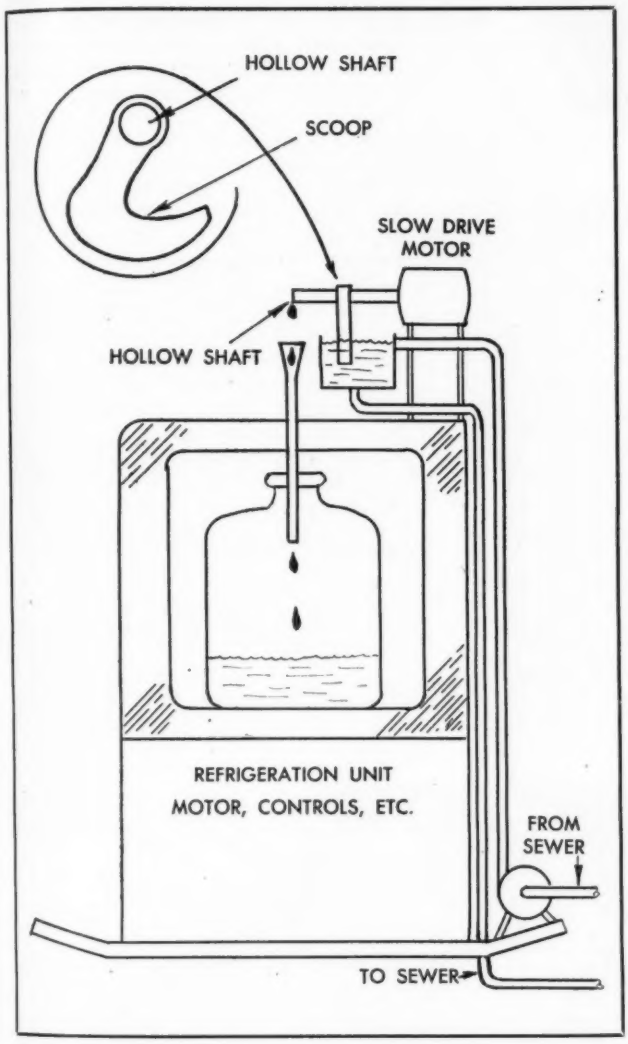

Fig. 3 — Simplified sketch showing Atlantic Refining Co.'s arrangement for securing refrigerated samples of waste waters

ADOPTION of a routine check on bacteria count in the effluent waste water from the Philadelphia refinery at Atlantic Refining Co. necessitated the development of a satisfactory means for obtaining proper samples. The waste disposal department specified that a definite and representative quantity of sewer effluent be collected during a definite period of time, and that the sample be maintained at a constant temperature of 42° F. so that bacteria would neither die nor multiply.

The solution as worked out by Atlantic's instrument department is the device illustrated in the sketch in Fig. 1. A standard commercial refrigerator unit was built into a specially insulated cabinet designed to accommodate a 5-gal. glass jar.

In operation, a small circulating pump picks up effluent and sends it to a small trough mounted on top of the cabinet. Weirs in the outlet of the trough maintain a constant level; overflow passes back to the sewer. A small scoop, rotating at slow speed and mounted on a hollow shaft picks up a definite quantity of effluent on each revolution through the trough. Samples thus picked up pass out the end of the hollow shaft and flow through a funnel in the top of the cabinet to the 5-gal. jar.

The sampling rate can be varied between desired limits; in this case, 3 to 5 gals./24 hrs., by adjusting the level in the trough by raising or lowering the weirs. Rotational speed of the scoop is constant. The cabinet and accessory equipment are all mounted on skids for easy movement to various locations in the refinery sewer system. The entire unit operates on 115 volts, 60 cycles, A.C. current.

Because of the critical nature of constant temperature to the routine bacteria count, the sampling device is always used, regardless of atmospheric temperatures.

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Laboratory Practices

Extreme-pressure Apparatus Modified For Long-time High-torque Gear Tests

ACCURATE measurements of wear with various automotive gear lubricants under simulated service conditions can be obtained from a modified SAE extreme-pressure lubricant testing machine, according to recent investigations by S. A. McKee, J. F. Swindells, H. S. White, and Wayne Mountjoy of the National Bureau of Standards.

The modified SAE apparatus provides a sensitive means for the evaluation of lubricants with respect to wear at high torque and low-speed operation, the Bureau engineers state. It was designed originally for testing load-carrying capacity of gear lubes under fixed high-speed and shock-loading. The new test makes it possible to detect any significant difference in the performance of lubes meeting requirements of the same specifications.

In normal operation, the SAE machine has two contacting cylindrical test cups which are rotated at different speeds under load, providing a combined rubbing and rolling action typical of loaded gear teeth. It is particularly adaptable for wear tests because the test specimens are of such size and shape that accurate indications of wear may be obtained by determination of loss in weight. Also, any wear that occurs on the test cups does not materially affect the area of contact under a given load.

On the other hand, the method of lubricating the test surfaces is not especially suitable for long-time tests, and the modification of the machine was made with this factor in mind. At the same time, it was decided also to provide better temperature control of the upper test cup.

In the original machine, the lower test cup is supported half immersed in a small oil box. Lubrication between the two cups is effected by the oil carried up as the lower cup rotates. Since only the lower cup is cooled by immersion in the oil bath, the upper cup runs at a considerably higher temperature. This usually is quite noticeable in the load-carrying capacity tests. For this reason, an additional oil reservoir of larger capacity and a circulating system were provided for applying a stream of oil to the upper test cup.

The modification is shown in the photograph, Fig. 1. Oil being tested is drawn from reservoir *A* by a small motor-driven pump *B* and delivered through ¼-in. pipe *C* to the top of the upper test cup, which has been covered by a special oil splash guard *D*. The oil then drains to the oil box *E*, which is fitted with two ¼-in. overflow pipes *F*, so located that the oil level in the box partially immerses the lower test cup. Oil from the overflow falls into open fittings in the ¾-in. drain pipe *G* and returns to the reservoir *A*.

Heaters are provided at the reservoir, at *J*, and on the delivery pipe, at *K*. Thermocouples *H*, in the reservoir *A* and in the oil box *E*, provide means for temperature measurement and control. Counterbalanced overflow pipes, splash guards, and an oil thrower all prevent excessive oil leakage around the test cups and oil box.

Lubricants used in the Bureau's investigations of the modified test apparatus were SAE 90 grade and included: (1) a Navy contract 1080 mineral oil; (2) five lubricants conforming to US Army Specification 2-105-B; (3) five lubricants conforming to Federal Specification VV-L-761; and (4) one lead-soap active-sulfur lubricant.

In these wear tests, the upper cup is driven at 500 rpm. with a 3.4-1 gear ratio between the upper and lower cups, thus providing a 2.4-1 ratio of rubbing to rolling at the contacting surfaces. The specimens, steel Timken test cups (T-48651), have an average (root mean square) surface roughness of from 25 to 30 micro-inches as measured with a Profilometer. Each lubricant sample (two quarts) is circulated at a rate of about 500 grams/minute. With a constant oil temperature of 225° F., tests were made at constant loads of

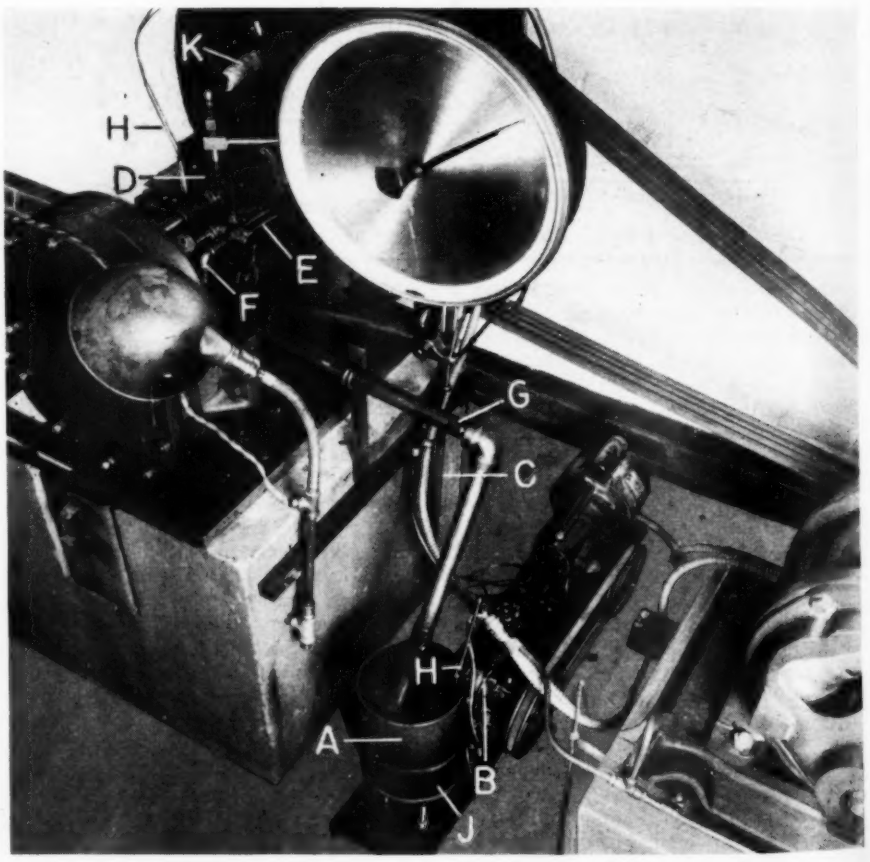
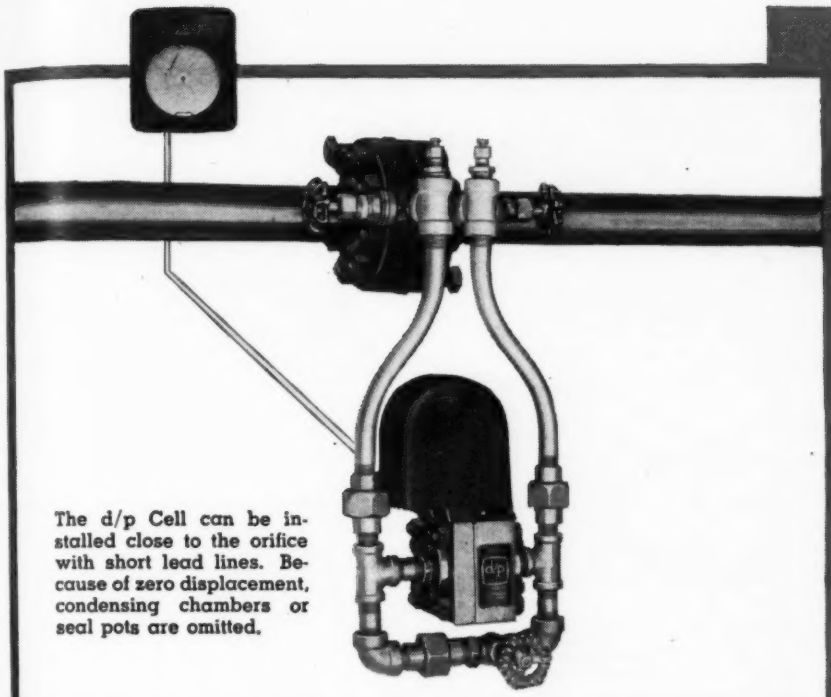


Fig. 1—The SAE extreme-pressure lubricants testing machine, as modified by the National Bureau of Standards



The d/p Cell can be installed close to the orifice with short lead lines. Because of zero displacement, condensing chambers or seal pots are omitted.

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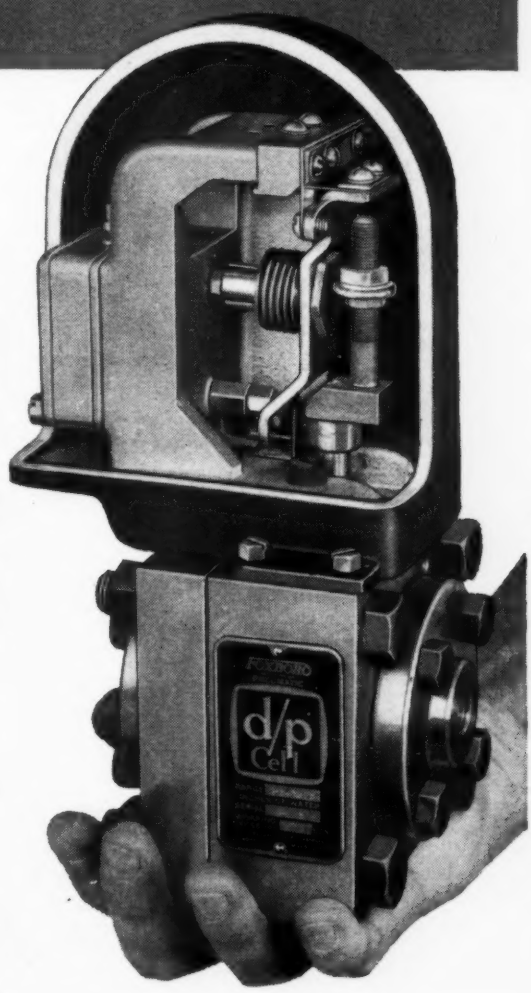

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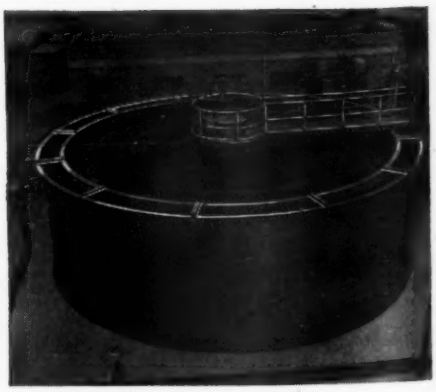

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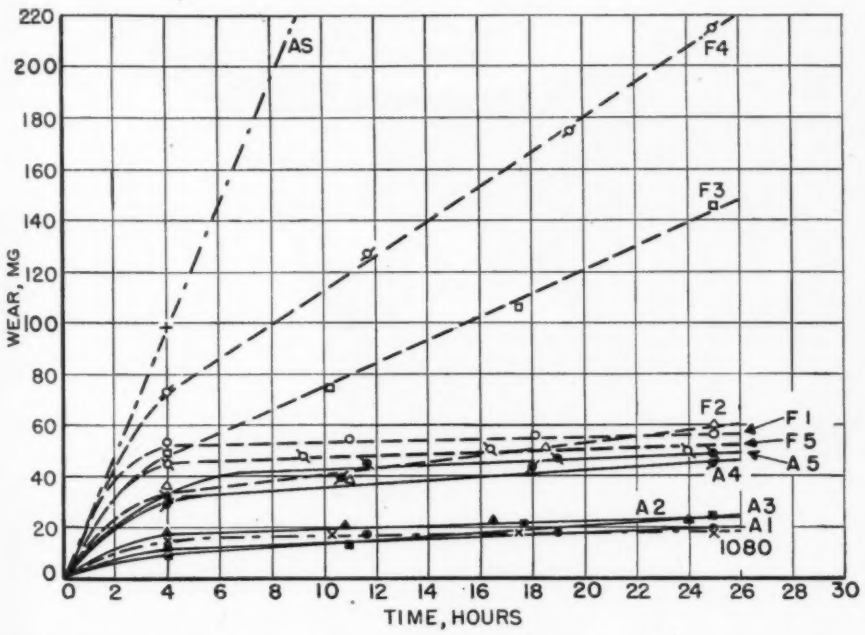
90, 135, 180, and 225 lbs. (scale readings). The loading system is such that the corresponding loads on the 2-in. diameter by ½-in. test cups are ten times the scale readings. Tests also were made at 250° F. and 180-lb. load. The above conditions approximate the range of conditions covered in the usual high-torque low-speed gear tests.

Test cups are weighed before and after each period of operation, the loss in weight being used as a measure of wear during the test period. At the beginning of the Bureau's investigations, weighings were made at frequent intervals, and the tests run as long as 75 hrs. It was found, however, that representative data could be obtained by operating for about 25 hrs., with weighings after 4, 11, 18, and 25 hrs. operation.

In general, the data obtained indicate that there is a run-in period of high rate of wear for a few hours, after which the wear settles down to a fairly constant rate. The line graph of the data, Fig. 2, shows that the straight portion of the curve usually is well established by 25 hrs. of operation. The slope of this portion of the curve is more significant from the standpoint of estimating gear life than is the observed loss in weight for any given length of time.

Although wear data with hypoid gears are not available for a direct comparison, it is believed that these results are in reasonable agreement with the known service performance with these lubricants. The wear with the mineral oil was low up to the point where it would not carry the load, while with the lead-soap active-sulfur lubricant (which will carry a high shock load) the wear was relatively high at all but the lightest load.



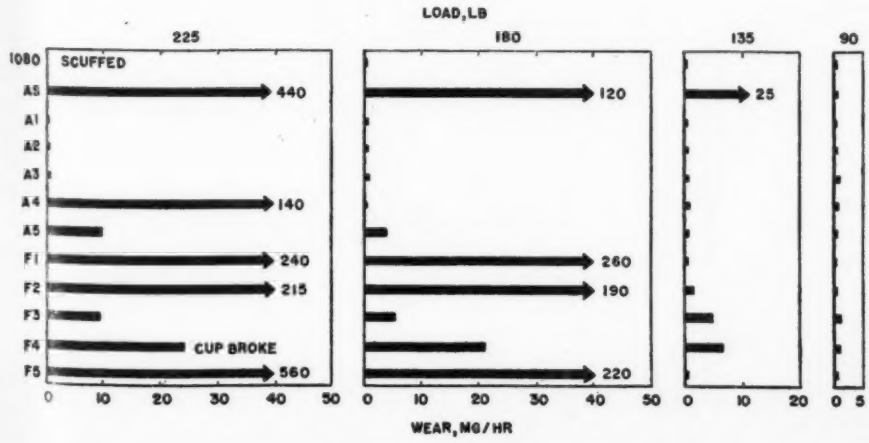


Fig. 2—Above: wear vs. time curves for all lubes in test program with modified apparatus. Below: rate of wear (after run-in period). Oils are identified by the symbols as follows; mineral oil, 1080; lead-soap active-sulfur lubes, AS; Army specification lubes, A1 through A5; federal specification lubes, F1 through F5

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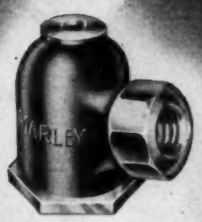

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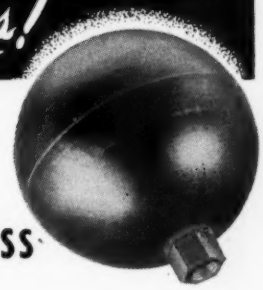

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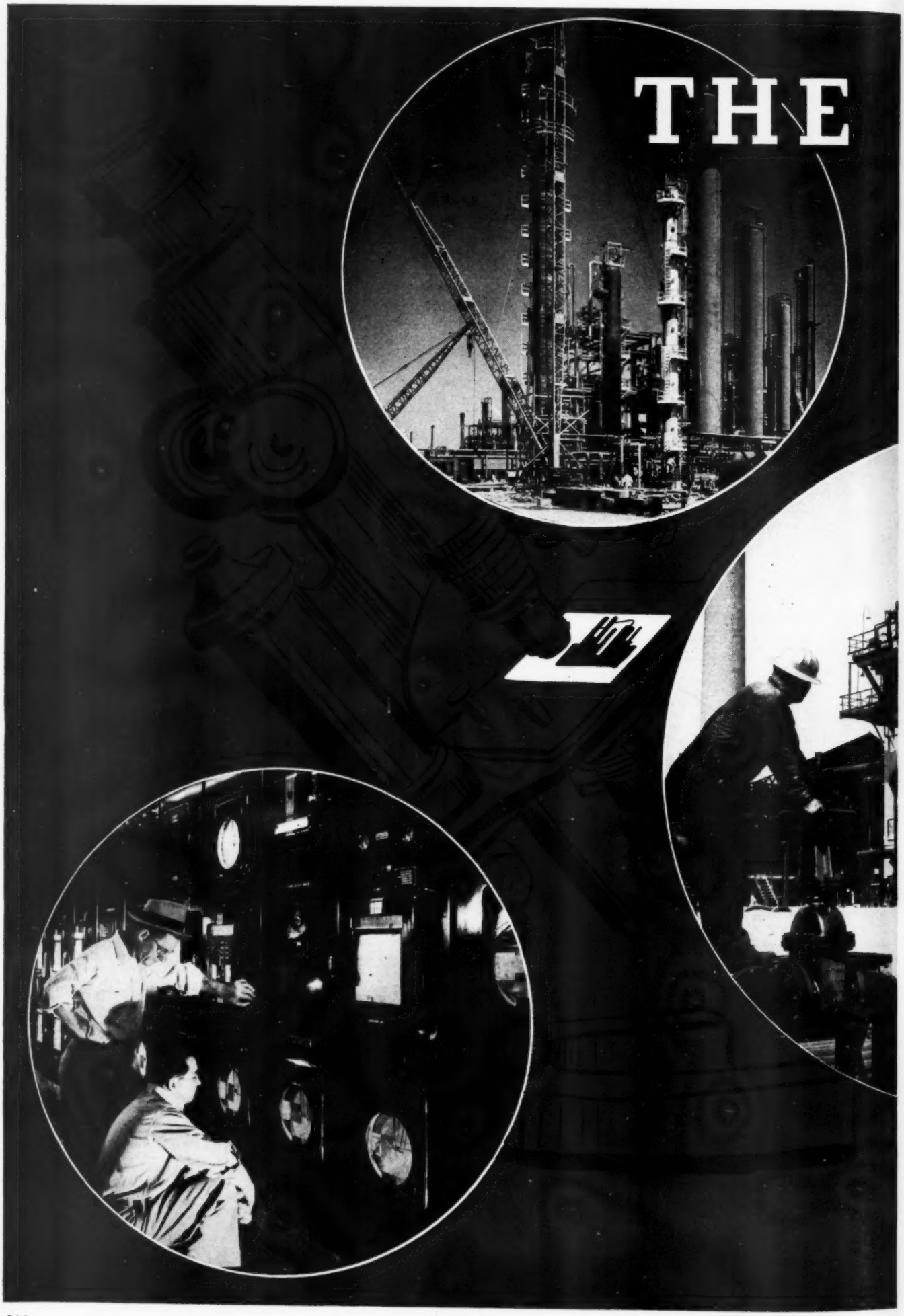
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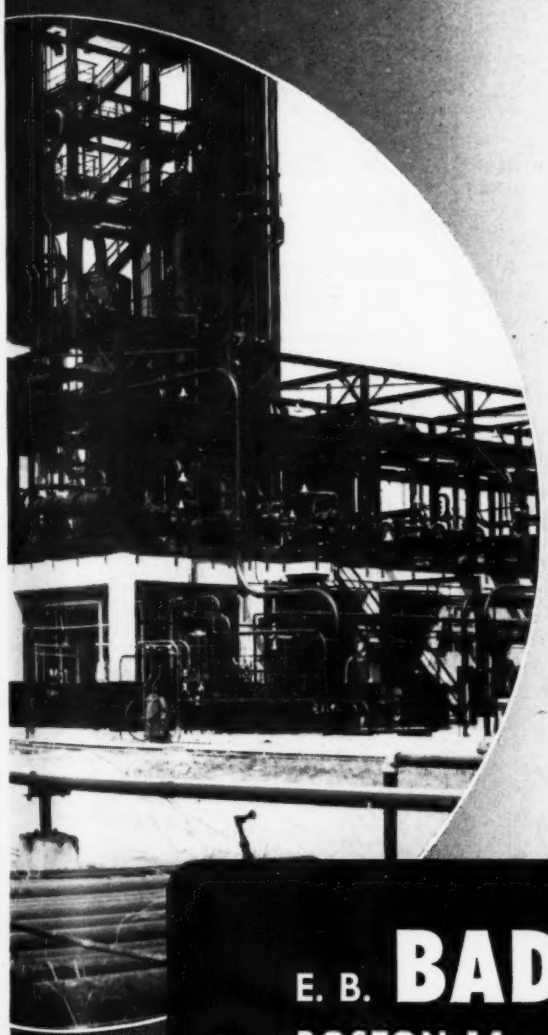

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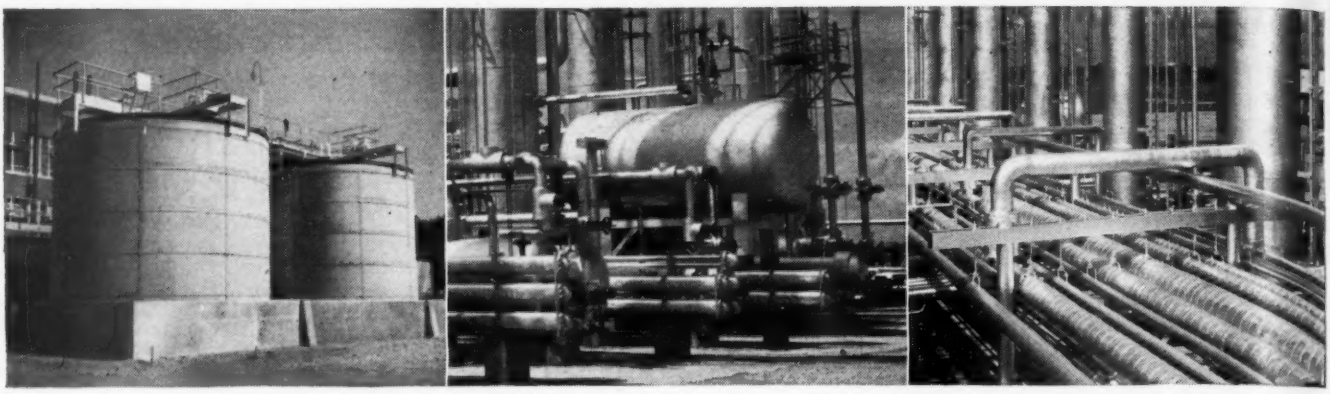

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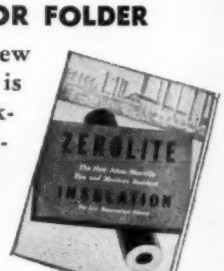

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Patent Trends in Petroleum Refining

By Peter J. Gaylor, Editor "The Technical Survey"

Catalytic Reforming of Naphthas

THE term "naphtha reforming" is an all-inclusive one identifying the method of improving antiknock properties and volatility of heavy naphthas or gasoline, especially low octane-number paraffinic stocks such as straight run distillates. The improvement is accomplished by thermal treatment in presence of a catalyst. Some "reforming" usually takes place during catalytic cracking or destructive hydrogenation.

In the reforming process, a number of reactions occur, the predominating ones being cyclization (mainly aromatization), isomerization, dehydrogenation (which usually accompanies aromatization), and cracking. Deposition of carbon on the catalyst generally takes place, and for this reason the process might be called a decarbonation. This carbonaceous film gradually inactivates the catalyst and necessitates periodic regeneration by burning or steaming.

Types of Reforming Processes

Reforming in presence of hydrogen is known as *hydroforming* and the main advantage for this process is the suppression of carbon formation by the hydrogen used in the reaction. This term includes *platforming*,[1] an aromatization process introduced by Universal Oil Products Co., using straight run gasoline as feed stock and a platinum catalyst with a hydrogen cycle.

Cycloversion,[2] as practiced by Phillips Petroleum Co., usually involves passing a gasoline fraction (with steam) over a cyclization catalyst to produce a highly aromatic product low in olefins, while *isoforming*[3] (which was introduced by Standard Oil Co. of Indiana) employs a cracked naphtha feed stock which is passed over a synthetic gel catalyst, and is thus more restricted to olefin isomerization and cyclization.

From a chemical point of view, we might define reforming (to differentiate it from other reactions of pure hydrocarbons) as the changing of the molecular skeletal structure without altering the number of carbon atoms. Such a definition would exclude cracking, which generally occurs to an appreciable extent in catalytic naphtha reforming, and for this reason the word "reforming" has a special meaning when used in the case of naphtha. The operation is conducted for the same purposes as in the case of thermal reforming, i.e. to (1) improve octane number, (2) increase volatility, (3) increase lead susceptibility, and (4) reduce sulfur content, the main advantage over the thermal process being the lower gas and tar (carbon) losses for a given increase in octane number obtained.

In one patent[32] Phillips Petroleum Co. discloses the use of bauxite impregnated with chromium oxide for use as a reforming catalyst. Natural bauxite at that time cost $44/ton, in place.

Houdry Process Corp.[4] also has described reforming of naphthas with a clay catalyst at about 850° F. A 56% yield of 300° F. end point aviation gasoline of 82 octane (3 cc. TEL) was obtained from Gulf Coast heavy naphtha, the acid heat being below 18. An activated magnesite catalyst has been employed by Universal Oil Products Co.[5]

In the cycloversion process, the gasoline product is said to have up to 90% aromatics and a very small amount of olefins. The principal by-products are normal and iso-butylenes. Catalyst regeneration is accomplished by burning off the carbon with steam and air.

Shell Oil has passed n-nonane over a catalyst[6] comprised of 70% chromium oxide and 30% alumina with potassia in the concentration of 18 parts/100 parts of the oxides, at 465° C. and atmospheric pressure, obtaining an 83 wt. % yield of liquid, 71% of which was aromatics, 6% olefins and 23% paraffins. About 80% of the aromatics consisted of methyl ethyl benzene.

Bauxite Catalyst Used

A bauxite catalyst[7] will give a 93% yield of product having a 24 octane number improvement from a South Texas straight run distillate of 26 octane. Porocel activated bauxite may be obtained by following a a heat activating technique.[8]

Without the use of catalysts, the main tendency for a paraffinic hydrocarbon is to crack to low molecular weight paraffinic and olefinic products. Since cyclic and branched chain hydrocarbons possess higher thermal stability, there is also a tendency for the cracked products to isomerize or cyclize, and, to a small extent, dehydrogenate and condense.

By the use of catalysts, however, it is possible to activate certain bonds, such as the $-C-H$ bond in the paraffinic hydrocarbon, so as to facilitate isomerization, dehydrogenation and similar reactions without much cracking. Unfortunately, this activation has not been developed to such a stage that these reactions could be carried out at low enough temperatures to the complete exclusion of the cracking reaction. For this reason, most reforming processes must be carried out at temperatures so close to the cracking range, even with catalysts, as to involve some cracking of the feed stock or products. Cyclization tendency of paraffines and olefins of over five carbon atoms is strong in the presence of reforming catalysts.

Employ Various Types of Clays

The antiknock value of gasoline has been improved by treating the superheated vapors (at 600-1500° F.) with bauxite, fuller's earth, acid treated or impregnated clays, synthetic clays, metal sulfides, etc.;[9] precipitated aluminum hydroxide with carbon black which is subsequently removed by oxidation;[10] also a mixture of 94% ferric hydroxide, 5% aluminum hydroxide and 1% potassium oxide.[11] Fulton[12] catalytically reforms a naphtha which had previously been reformed in the absence of catalysts, the latter merely increasing the octane number by increasing the amount of light ends (by cracking).

Universal Oil Products has described the improvement in octane number of gasoline by subjecting the vapors to 450-650° C. for 2-20 secs. in the presence of precipitated and calcined aluminum hydroxide containing 5-10% water.[13] Considerable hydrogen is liberated.

Antiknock properties of gasoline have been improved also by subjecting it, at elevated temperature, to the action of aluminum oxide containing an alkali metal and metals of Groups 4, 5, and 6 of the Periodic Table,[14] and catalysts containing refractory oxides and silicate base ma-

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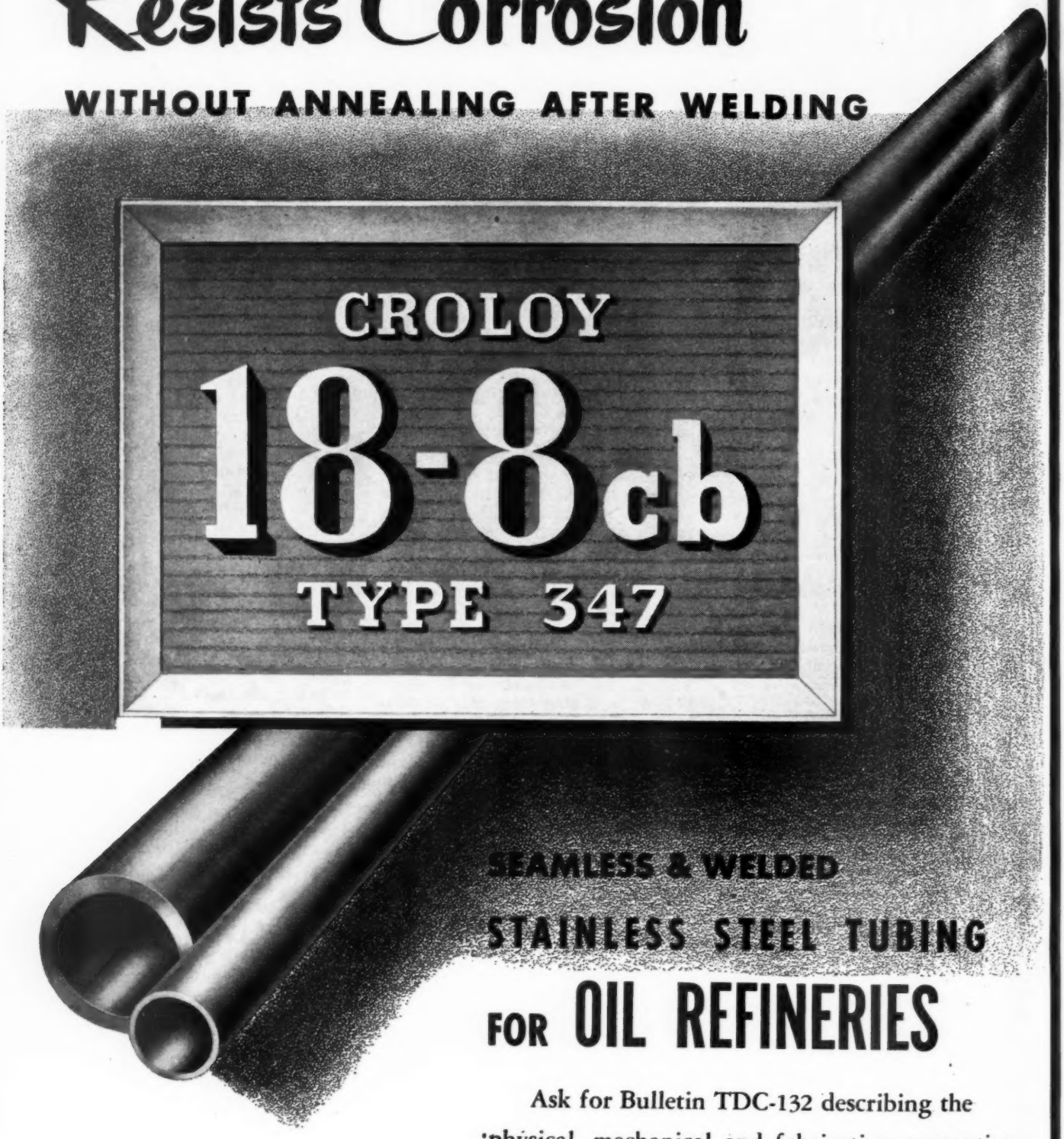

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terials of relatively low catalytic activity. The supports may be magnesia, alumina, Montmorillonite, etc., while the promoters are compounds of Groups 4, 5 and 6.[15] Phosphate catalysts, such as boron phosphate, also have been used for improving octane number of gaosline without excessive gas formation.[16] Isomerization of hydrocarbons has been claimed with activated fuller's earth, the activation being carried out with ammonia, nitric acid, hydrofluoric acid, fluorine, organic acids, or hydrocarbons containing chlorine or sulfur.[17] Activated clays and alumina have been employed for reforming naphtha at 480-565°.[18] Synthetic clays and dialyzed clays were also proposed for this purpose.[19]

Iron Chloride as a Catalyst

The octane number of gasoline may be improved by reforming in presence of a catalyst such as iron chloride and a small amount of tertiary alkyl halide.[20] In one example, octylene at 275° C. and 30 atm. pressure, in presence of magnesium pyrophosphate for four hours showed an octane number increase from 44 to 54 in presence, also, of tertiary butyl chloride, while in the absence of the chloride the increase was to 47.

Motor fuels also have been reformed at 450°-700° F. in presence of granular catalysts such as magnesia and less than 10% of added compounds such as lead chromate and zinc sulfate.[21] Antiknock improvement of naphthas is accomplished by passing over activated aluminous material at 900-1050° F. for a sufficient time to cause formation of not over 3% butanes.[22] The reforming of narrow gasoline fractions has been disclosed by Heinrich.[23] Left hand elements of Groups 4, 5 and 6 likewise have been disclosed as reforming catalysts.[24] Aluminum silicates, feldspars, zeolites and similar materials, modified with other metals were employed,[25] as well as a body of caliche of the limestone type.[26] The Texas Co. covered the use of bauxite containing nickel oxide for this purpose.[27]

Reform Raffinate to Avgas

The extraction of motor fuels with solvents having a selective solvent action for non-paraffinic constituents, and catalytically reforming the raffinate at 900-1050° F. to produce aviation fuel is disclosed in a Standard Oil Development patent.[28]

Shell Oil has described a process for increasing the branchiness of olefins by contacting them at 275-500° C. with hydrated alkali aluminum silicates of the permutit or zeolite type,[29] and Russian workers disclosed isomerization of olefins, such as butylene, with clay, floridin, aluminum sulfate, alumina, phosphoric acid on active carbon, and fire clay.[30] As far back as 1913, isopentenes were prepared by isomerizing normal pentenes over clay at 450° C.[31]

As to the use of platinum for cyclization of hydrocarbons, Serguienko disclosed the conversion of isoamyl benzene to beta methyl naphthalene, using platinized carbon and chroma-alumina catalysts.[33] Palladium on alumina or active carbon also gave a 95% conversion of dipentene to p-cymene.[34]

In olefins, there is a tendency of the double bond to shift to a more central position, with appreciable increase in octane number, as can be seen from the following:

Olefin	Blending Octane No.
Octene-1	41
Octene-2	54
Octene-3	69
Octene-4	83

Hence, any catalytic process which will facilitate this centralization of the double bond is of advantage in a reforming operation.

Mention also might be made of the *Catarole process* developed by Weizmann and now in operation in the Petrochemicals plant in England. Here, hydrocarbons are aromatized in presence of metals such as copper, and considerable olefinic gas formation takes place. The process becomes commercially profitable only if the gaseous products are converted into chemicals.[35]

Chromium Oxide Type Catalysts

M. W. Kellogg Co. has been interested in chromium oxide type catalysts for reforming reactions. In this connection, attention might be brought to some work in Europe[36] on cyclization of paraffins and olefins of eight atoms or more, involving more or less extensive cracking reactions. In presence of chromium oxide at 465° C. with 20 sec. contact time, cyclization of paraffins proceeds through dehydrogenation to the corresponding olefin. Naphthenes underwent no cracking. Chromium oxide was found to catalyze the shift of the double bond in the olefin to a more central location in the molecule.

Among the more recent patents[37] in the field of catalytic reforming is one issued to Phillips Petroleum Co., and covering the aromatization of parraffin hydrocarbons. The process involves heating the material to a temperature in the range of 1000 to 1200° F., and then passing it through alternating endothermic conversion zones and exothermic reaction zones, holding it in the conversion zone in the absence of any catalyst for a time of 0.05 to 1 sec., and in the reaction zone in contact with a mass of solid granular catalyst for a period of 0.5 to 2 secs.

There is considerable art on this subject and no attempt is made here to cover all of the developments in the field. However, a list[38] of additional patents and articles is included in the event a more detailed study of the subject is desired.

References

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(2) *Petr. Engr.*, Apr., 1943, pg. 98; *Oil & Gas Jour.*, Apr. 13, 1944, pg. 225; Buell et al, *Oil & Gas Jour.*, May 5, 1945, pg. 87.

(3) *Petr. Refiner Suppl.*, Apr., 1947, pg. 97.

(4) Peterkin, *National Petroleum News*, Nov. 29, 1939, pg. R-517.

(5) U.S. Patent 2,194,335, Universal Oil Products.

(6) U.S. Patent 2,271,751, Shell Development Co.

(7) Foster, *National Petroleum News*, Sept. 20, 1939, pg. R-394.

(8) King et al, *Oil & Gas Jour.*, Apr. 13, 1944, pg. 236.

(9) Miller et al, U.S. Patent 1,895,081 (1933); Texaco, Canadian Patent 329,501-3 (1931).

(10) Schulze, U.S. Patent 2,112,931 (1938).

(11) Kuentzel et al, U.S. Patent 2,129,142 (1938).

(12) Fulton, U.S. Patent 2,125,714 (1938).

(13) British Patent 498,247; Cf. Canadian Patent 377,047; U.S. Patent 2,096,769, Continental Oil Co.; U.S. Patent 1,895,081.

(14) U.S. Patent 2,172,534-5 (1939), Universal Oil Products.

(15) Canadian Patent 379,938, Universal Oil Products.

(16) Dutch Patent 41,666, Shell Oil Co.; French Patent 795,726.

(17) French Patent 814,334, I.H.P.

(18) French Patent 811,792, Standard Oil Development Co.

(19) British Patent 468,488, Standard Oil Development Co.; British Patent 470,588; British Patent 475,125; French Patent 806,847; Canadian Patent 369,110, Houdry.

(20) U.S. Patent 2,105,950, Shell.

(21) British Patent 478,996, Universal Oil Products; French Patent 825,206.

(22) Canadian Patent 374,421, Cross.

(23) Canadian Patent 375,717, Heinrich.

(24) British Patent 490,695, Universal Oil Products.

(25) French Patent 825,207, Universal Oil Products; Indian Patent 23,869; British Patent 501,896, Shell.

(26) U.S. Patent 2,127,953 (1938), Drennan.

(27) U.S. Patent 2,086,287, The Texas Co.

(28) U.S. Patent 2,146,039 (1939), Whiteley.

(29) British Patent 501,896, Shell.

(30) Rudkovskii et al, *Compt. Rend. USSR*, 4, no. 8, pg. 359 (1936).

(31) German Patent 263,017 (1913), Bayer.

(32) U.S. Patent 2,183,591, Phillips Petroleum Co.

(33) Serguienko, *Doklady*, 27, no. 9 (1940); Kazanskii et al, *J. Gen. Chem.*, 9, no. 46, pg. 496 (1939).

(34) U.S. Patent 2,272,711, American Cyanamid Co.

(35) *Chem. Trade Jour.*, Apr. 18, 1947, pg. 364.

(36) Hoog et al, *Trans. Faraday Soc.*, 35, 993, 1008 (1939).

(37) U. S. Patent 2,439,934 (1948), Phillips Petroleum Co.

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U.S. Patents:

1,895,081	2,228,118	2,394,796	2,413,312
1,960,977	2,228,724	2,394,849	2,414,951
2,086,287	2,231,803	2,395,016	2,419,997
2,096,769	2,231,813	2,395,048	2,420,563
2,126,817	2,232,736	2,395,680	2,422,884
2,160,249	2,234,538	2,399,765	2,423,947
2,167,602	2,241,430	2,399,751	2,424,636
2,180,372	2,245,735	2,399,805	2,424,637
2,181,877	2,246,643	2,399,895	2,432,286
2,183,591	2,391,962	2,403,650	2,437,532
2,194,335	2,392,248	2,408,139	2,439,811
2,198,545	2,392,588	2,408,140	2,439,934
2,201,306	2,393,288	2,408,948	2,443,285
2,202,401	2,393,537	2,409,353	2,445,345
2,203,825	2,394,651	2,409,695	2,447,016
2,203,836	2,394,739	2,412,828	2,447,017

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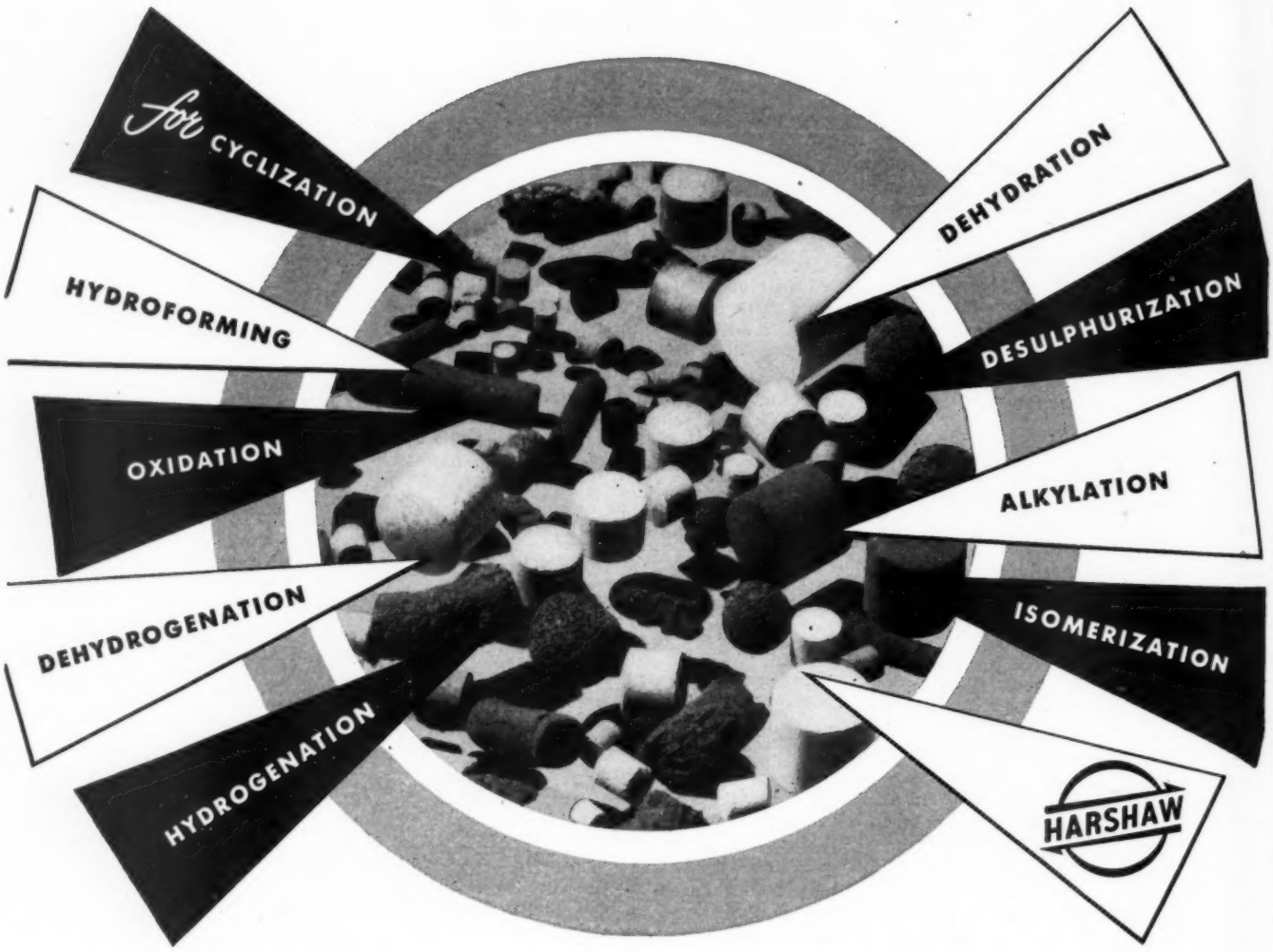

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Extraction Efficiency Increased In Combination Solvent Tower

In addition to the solvent extraction column described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have been issued recently includes a novel separator that uses a screen to remove oil from refinery waste water.

IMPROVED EXTRACTIVE efficiency can be obtained in a counter-current, solvent extraction tower such as is used for refining of lube oils by installing within the tower equipment which will produce, in effect, a combination of conventional counter-current operation with stage counterflow operation.

In the drawing in Fig. 1 this equipment is shown in the central portion of the column, as installed between two sections of packing. It consists essentially of a conical baffle 18, which provides chamber 20 to collect the relatively warm, intermediate extract phase flowing downwardly from the upper portion of the tower.

This liquid passes through conduits 22 leading to a central trap 24 and is drawn off by pump 26, which also acts as a mixer for the material. It is cooled and returned via line 28 to distributing spray ring 29. At the same time, the solvent phase is prevented from passing downward because of baffle 31. Thus there is a complete assurance that the solvent from the upper portion of the tower cannot pass directly through the mixed phase portion to the bottom of the tower.

U. S. 2,468,044, issued April 26, 1949, to Hyman R. Davis, assignor to The Lummus Co., New York, N. Y.

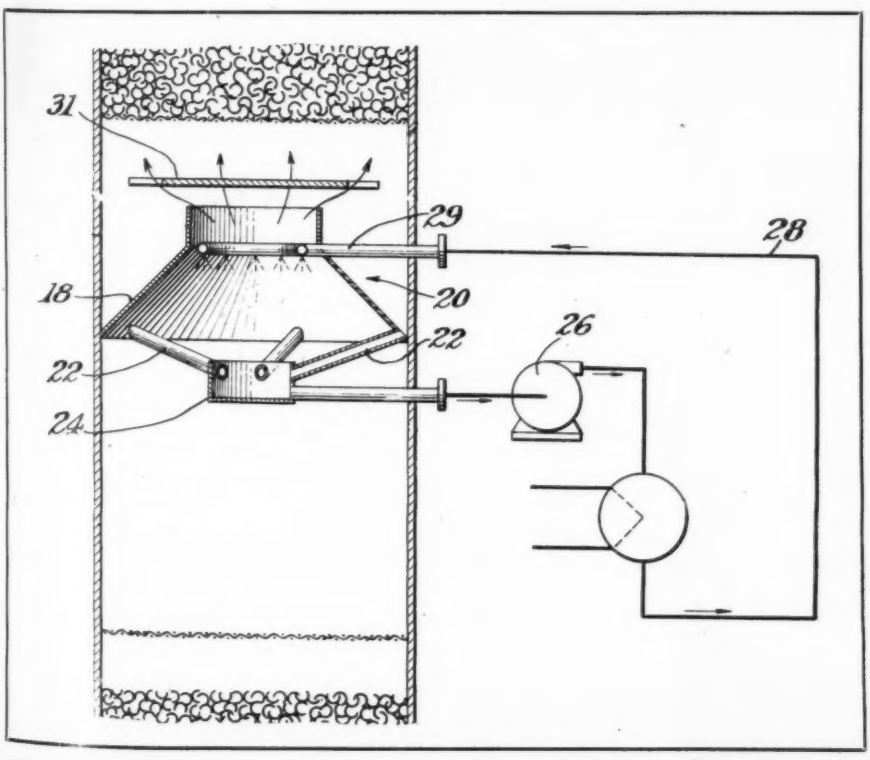


Fig. 1—Counter-current, solvent extraction column includes baffles 18 and 31 to provide the high efficiency of stage operation (U. S. 2,468,044)

Novel Separator Uses Screen To Remove Oil from Wastes

A SKIMMING DEVICE for separating waste oil from refinery effluent water is based upon the preferential adherence of oily materials over water for metallic screening of fine mesh, such as common mosquito screen, fabricated from copper or other corrosion-resistant alloys. When the screen holding the oil is then passed under a stream of air, the oil can be separated easily from the screen.

The cross-sectional view in Fig. 2 shows the general construction of such a skimmer. The screening is formed into a cylinder 10, connected to circular discs 12 at each end, also made of corrosion-resistant material. Within this drum is a long, narrow trough 18. A slotted pipe 20, immediately above the cylinder, passes air through the screen and carries into the trough 18 the oil which has been picked up by the screen. The oil then flows out through hollow shaft 14 to any suitable receiver.

The screen drum is rotated slowly by any convenient drive means, and in the same direction as the flow of the oil-laden water effluent in which it is immersed slightly. The size of the sceen mesh, the speed of rotation of the drum, and the velocity of the air stream must be varied according to the nature of the oily waste being removed.

U. S. 2,470,419, issued May 17, 1949, to Jules Verner, assignor to Standard Oil Development Co., Linden, N. J.

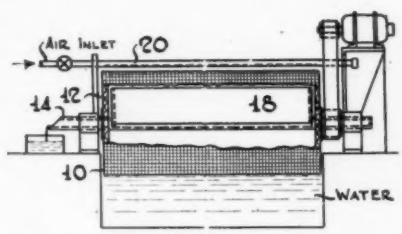


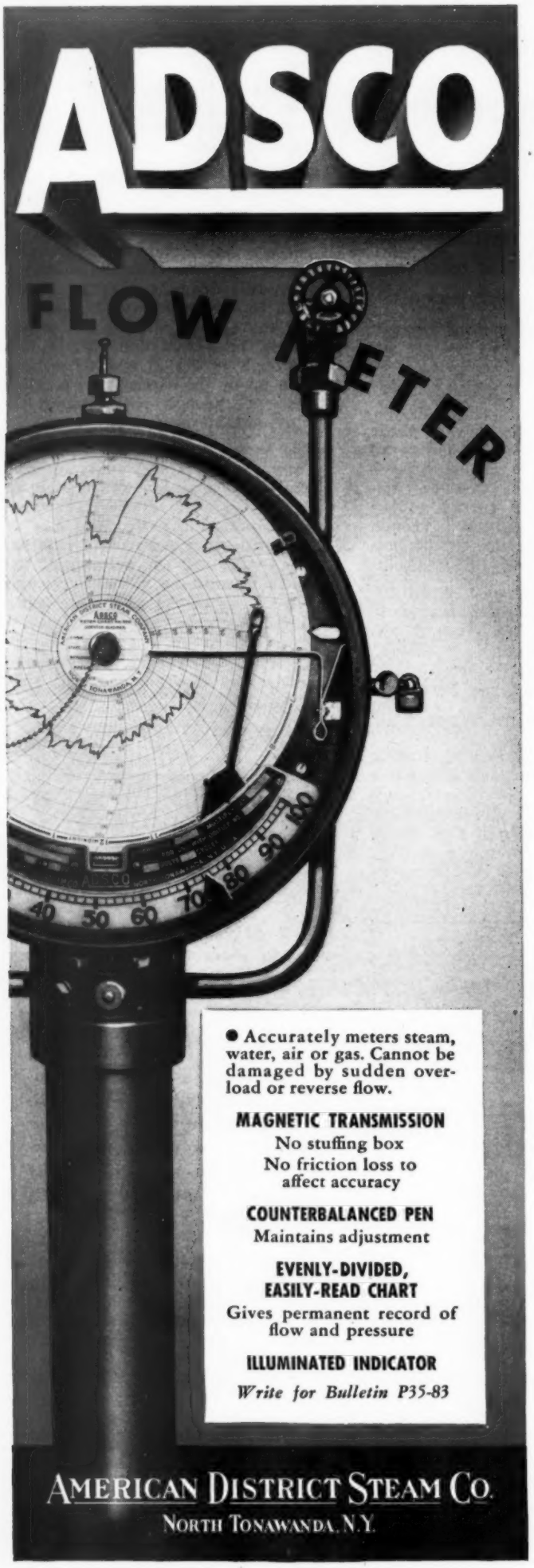
Fig. 2—Skimming device using wire mesh to separate oil from refinery waste water (U. S. 2,470,418)

Other Recent Patents

Space does not permit the complete review of all patents issued recently on equipment for the petroleum processing industry. Following, however, are brief abstracts of those with the greatest interest.

Mass Spectrometer for continuous analysis of petroleum hydrocarbon process streams which includes a high speed recorder and a multiple range controller. U. S. 2,470,745 issued May 17, 1949, to Carleton H. Schlesman, assignor to Socony-Vacuum Oil Co., Inc.

Catalytic Cracking Unit in which flow in the proper direction is maintained through the several recirculation lines and heat exchangers, a condition most difficult to control during start-up when the density of the fluidized streams is lowest. U. S. 2,-



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Equipment Patent Review

470,395, issued May 17, 1949, to Edwin J. Gohr and Charles W. Tyson, assignors to Standard Oil Development Co.

Crude Oil Separator and emulsion breaker of an improved design for continuous operation with low evaporation losses and capable of breaking tight emulsions without the aid of filters. U. S. 2,468,958, issued May 3, 1949, to Arthur V. B. Candler, assignor to Maloney-Crawford Tank & Mfg. Co., Tulsa, Okla.

Spectrophotometer for continuous analysis of a stream of hydrocarbon gases in which close control is maintained over variations in the intensity of the source of radiations of the ultra-violet light. U. S. 2,468,638, issued April 26, 1949, to Eugene J. Rosenbaum, assignor to Sun Oil Co.

Fractionation Column Control by which maximum allowable vapor rate is obtained through utilization of the increase in liquid level on a selected plate, as flooding begins, either to operate a signal to warn the operator or to actuate control valves governing the various feed rates. U. S. 2,467,174, issued April 12, 1949, to Glenn W. Wilson, Jr., assignor to Standard Oil Development Co.

Internal Expanding Wrench which comprises a set of radially-mounted dogs designed to grip the inner wall of a pipe in order to rotate it when there is no possible way to use a conventional pipe wrench. U. S. 2,468,867, issued May 3, 1949, to Elvin B. Collins, Calvert, Texas.

Rectification Column from which a relatively pure side stream of narrow boiling range can be obtained, in addition to pure overhead and bottoms products, through use of a vertical partition that provides an inexpensive, internal stripping section. U. S. 2,471,134, issued May 24, 1949, to Richard O. Wright, assignor to Standard Oil Development Co.

Mercury-operated Safety Switch for laboratory apparatus, where the mercury is held in the "on" position by the pressure of flowing liquid and is moved to the "off" position by failure of the liquid flow. U. S. 2,471,281, issued May 24, 1949 to Leonard E. Olson and Richard Wertzler, assignors to Sinclair Refining Co.

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Readers may obtain copies of any U. S. patents from the Patent Office at 25 cents each. Order by patent number direct from: The Commissioner of Patents, Washington 25, D. C.

What's New!

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

Reviewed by WILLIAM C. UHL, Equipment Editor

1—Low-cost Jacket Fastener

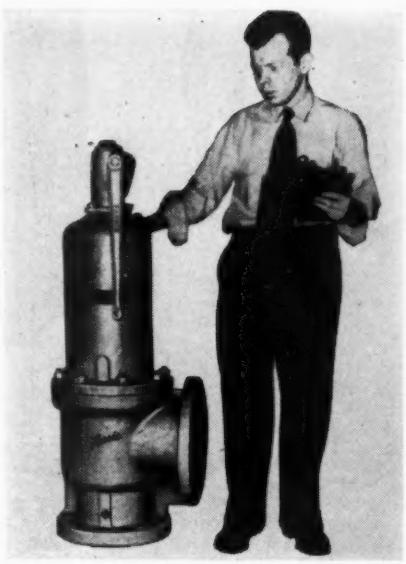
Labor costs are said to be cut as much as 75% with a new method for applying protective metal jacketing over insulated pipelines, developed jointly by Minnesota Mining & Mfg. Co. and Childers Mfg. Co. The jacketing is a light weight, corrugated aluminum sheet and it is taped to the lines by bands of Minnesota's No. 471 Plastic Film Scotch Tape. The tape is said to stand up indefinitely under adverse weather conditions, temperatures from sub-zero up to 170° F., and acids, alkalis, and most hydrocarbons. Field tests showed installation cost to be less than 6c/sq. ft. (using $1.50/hr. unskilled labor.) This contrasts to labor costs running from 15 to 35c/sq. ft. for conventional methods. Childers Mfg. Co.

2—Safe Communication System

The new "Executone" Explosion-proof Intercom System has Underwriters' Laboratories approval for Class I, Group D hazardous areas, which includes atmospheres containing gasoline, petroleum, naphtha, benzine, alcohols, acetone, benzol, lacquer, solvent vapors, or natural gas. A feature of this electronic system is its full selectivity—stations in hazardous areas can call other stations in either hazardous or non-hazardous areas. Another feature is its so-called "remote reply". The person called can answer from any reasonable distance without stopping work or manipulating switches in the set. Executone, Inc.

3—Refinery Relief Valve

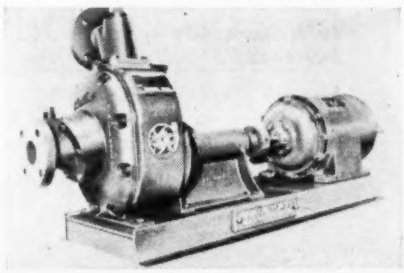
Reported to be the largest nozzle type safety-relief valve ever made, the new Farris model with 8-in. inlet and 10-in. outlet has been designed for refineries where low pressures and high temperatures are involved. One of its first uses was for top tower work on hydrocarbon vapors, in which application a number of valves already have been in service. Orifice diameter is 5 in., with an area of 19.635 sq. in. Valve is designed for top pressure of 300 psi. Body is of cast steel with stainless steel trim. Overall height is 46 in. with plain cap, or 50 in. with packed cap. Valve



is API-ASME coded and has a certified lift of ¼ of diameter of nozzle. Weight is 975 lbs. At 100 psi., valve relieves 116,000 lbs. of saturated steam. With water at 100 psi., it will pass 5,350 gpm. at 25% overpressure. Farris Engrg. Corp.

4—Centrifugal Pumps

A line of self-priming centrifugal pumps has been expanded to include 26 basic series which in turn are available in a virtually endless line of modifications and combinations of mountings, fittings, and materials. Design changes on basic models include a new cover plate for increased strength, flanged suction and discharge connections, and improved suction check valve. Marlow Pumps.



More "What's New!" Items, p. 818

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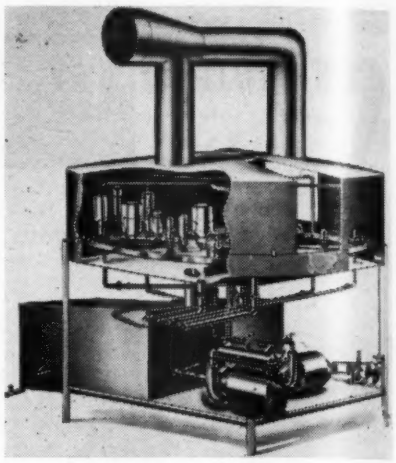
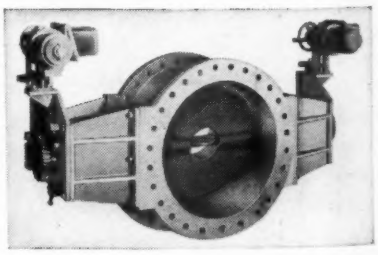
What's New!

5—Laboratry Bottle Washer



The Ogden Bottle Washer, developed in co-operation with two refining companies for their specialized use, now is available in production models. Test models installed ten years ago in Shell and Standard Oil plants are said to be still operating efficiently and to have paid for themselves in less than one year. In one comparison, the unit reduced labor from 240 to 40 man-hrs. per week to handle the normal bottle washing needs. The washer is self-contained with a production rate up to eight bottles per minute, using one operator. It will accommodate all sizes up to one gallon. Sequence of operations provides five steps: preliminary hot water rinse, wet steam rinse, water-soluble detergent wash (eliminating fire hazard), clean hot water wash, and hot air drying period. Ogden Filter Co.

6—High Temperature Valve

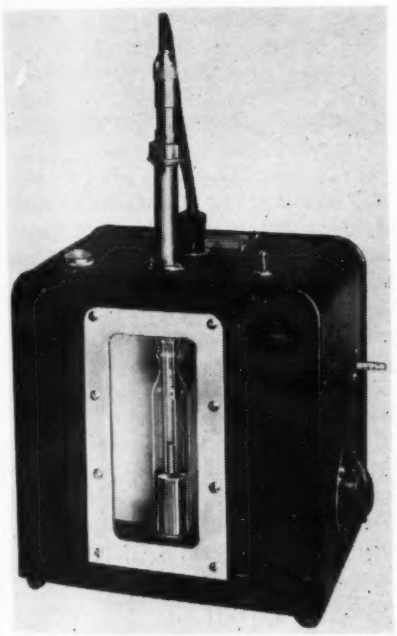


R-S Valve No. 725, a 36 x 8 in., 150 lb., Class B Steel Dual Valve, has been developed for an operating temperature of 1000° F. Body casting is chrome moly steel. Powered by separate electric motors, each alloy steel vane is operated independently of the other, insuring close control of volume and pressure. The valve is designed for either a high pressure drop and small volume, or a low pressure drop and large volume. R-S Products Co.

What's New!

7—Petroleum Products Meter

Features of a new line of "BiRotor" all-steel, positive-displacement type, meters for petroleum products include interchangeable measuring unit assembly, comprised of two synchronized, helical rotors which rotate freely in complete static and dynamic balance under all operating conditions. Meters range in size from 1½ to 8 in. and working pressures from 125 to 1000 psi., and are designed for pump or gravity operation. Units for loading racks, pipe lines, and the like handle capacities up to 350 gpm., those for transports, tank cars, barges, and ships range from 800 to 1300 gpm. on light oils. Ralph N. Brodie Co., Inc.



8—Molecular Weight Apparatus

Providing a complete "package" which requires no auxiliary equipment, the new Precision Cryoscopic Molecular Weight Apparatus utilizes the freezing point method and can handle both liquids or solids. Developed by Precision Scientific Co. in co-operation with Shell Development Co., it also can be used for rapid determination of freezing points of liquids or cooling curves of liquids. There is no separate insulated air jacket or ice bath to set up. Operator has finger-tip controls for tube heat, vacuum, tube motor, venting, dry air, and cooling. In addition, there is a milliammeter and a pressure gage indicating inches of water. Apparatus operates on regular 115 volts A.C. Precision Scientific Co.

More "What's New!" Items, p. 820

B.T.U. digest

THROWING LIGHT ON HEAT TRANSFER PROBLEMS

THE WHITLOCK MANUFACTURING COMPANY

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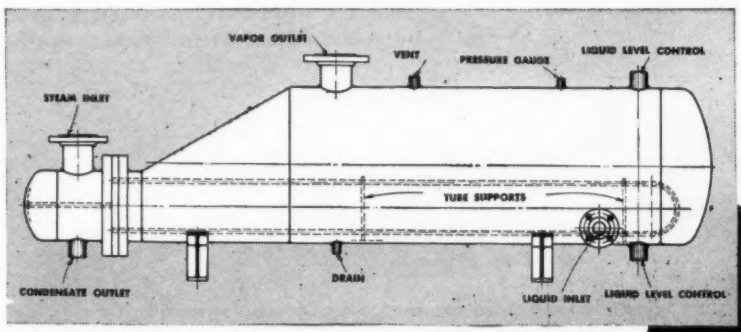
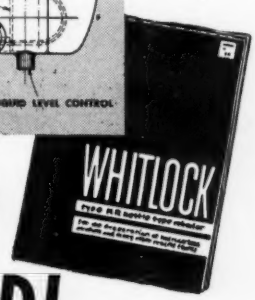
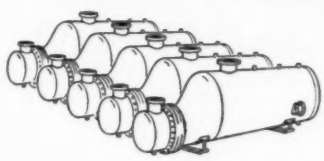




WHITLOCK REBOILERS NOW STANDARDIZED!



THERMAL DESIGN

The Whitlock Type KR Kettle Type Reboiler has now been designed to meet the need of industry for a standard, low-cost vaporizer adapted to multi-purpose process requirements. Using propane as an example, standard sizes provide vaporizing rates ranging from approximately 1,000 to 12,000 lbs. per hour. The Type KR Reboiler is of all-steel construction and is ideal for any service where conditions are non-corrosive to steel. The overall design results in standard reboilers answering the requirements of a wide range of individual operating conditions. Maximum heat flux, boiling rates, fluid velocities, vapor disengagements—these and other factors are considered as they relate to a given installation, and represent the background for each Whitlock recommendation.

MECHANICAL AND PHYSICAL DESIGN

The Type KR Reboiler is of a U-tube design which has proved so satisfactory for steam-tube service. With the eccentric conical port head, the tube bundle is placed low in the shell, thus minimizing the shell size. While we have discussed only the standard all-steel construction, corrosion-resistant materials may be utilized where process fluids make it advisable. Whitlock Bulletin No. 130, issued recently, gives a detailed description of these standardized reboilers. Why not send for your free copy?

SIZE NO.	APPROX. VAPOR RATE LBS./HR.*	OVERALL LENGTH	SHELL DIAMETER	CHANNEL DIAMETER	VAPOR OUTLET	LIQUID INLET	STEAM INLET	CONDENSATE OUTLET
1	915	7′ 0″	18″	6″	2″	1″	2″	½″
2	1,830	7′ 4″	18″	8″	3″	1¼″	2½″	½″
3	3,050	7′ 3″	24″	10″	4″	1½″	3″	¾″
4	6,100	12′ 6″	24″	10″	4″	2″	4″	1″
5	9,150	13′ 0″	30″	12″	5″	3″	4″	1¼″
6	12,200	13′ 6″	30″	14″	6″	3″	5″	1½″

* Approximate vapor rates based on heating propane from — 12° F. to 100° F. and vaporizing, when supplied with sufficient steam at 5 p.s.i.g.

WHITLOCK

DESIGNS and BUILDS Bends • Coils • Condensers • Coolers • Heat Exchangers Heaters • Piping • Pressure Vessels • Receivers • Reboilers

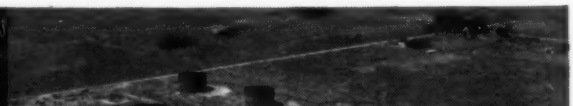
9—Multiple Level Gage

The "Varec" Electronic Gauger, available in both standard and explosion-proof models, provides remote liquid level readings for as many as 24 different storage tanks at one centrally-located panel. The receiving and indicating instrument shown in the photograph is a smaller, 10-station model. Two dials are used, one for feet up to 54 ft., the other for inches up to 12 by ⅛-in. divisions. Accuracy is said to be

within ±1/16 in., when the device is installed with the transmitters used in combination with "Varec" Automatic Float-Actuated Gauges. Depending on the connecting wire used, the receiver may be up to 10 miles from the transmitters. Receivers are designed for 110-115 v., 50-60 cycle AC power, and have a voltage regulating circuit to insure constant indicating accuracy through a supply voltage variation of from 85 to 130 v. Instant calibration checks may be made by a test push-button on the panel without removing the panel and chassis from the cabinet. Vapor Recovery Systems Co.

NATASCO

A MILLION DOLLAR INVESTMENT PROTECTED WITH NATASCO



(A NEW TANK FARM COMPLETED IN 1948)

The owner of this tank farm knows the value of Natasco products and service. The proper Natasco coatings were selected and then applied to the interior of these tanks by experienced Natasco workmen to provide the maximum protection from corrosion. Whether your tanks are just being erected or have been in service for years, Natasco protection will make them last many years longer at a reasonable cost and is *backed by the Natasco Guarantee.*

Why Natasco Products give longer life to tanks

1. They are insoluble in petroleum and petroleum vapors.
2. They are chemically inert in dilute solution of sulphuric and hydrochloric acids.
3. They are chemically inert to hydrogen sulphide.
4. They are impervious to gases.
5. They have high dielectric strength.
6. They are elastic, withstanding the stresses of expansion, contraction, and bending of metal without rupture.
7. They have adequate film thickness.
8. They adhere to metal, wood or cement.

Let Natasco's years of experience be your guide in proper tank protection. Telephone, call or write for complete information.

"KEEPS NEW TANKS NEW... MAKES OLD ONES DO..."

PROTECTS TANKS AGAINST CORROSION

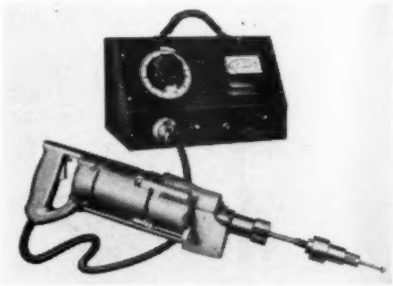
THE Natasco COMPANY

P. O. BOX 1318 TULSA, OKLAHOMA

Lease Tank Service—West Texas Area: Williams Construction Company Odessa, Texas

California Representative: Coast Contractors, Ltd. 4636 E. Slauson, Maywood, Cal.

10—Controlled Tube Roller

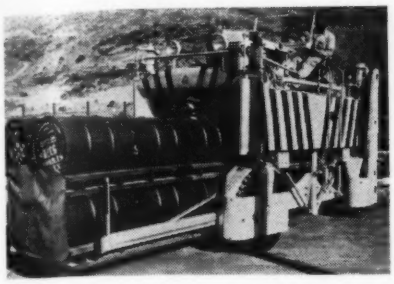


Eliminating the factor of human judgment in tube expanding operations, the new Airetool-Fisher Electric Tube Rolling Control uses mechanical means to determine the precise moment when the tube joint in the tube sheet has reached the optimum degree of tightness. The expanding system consists of the control mechanism, operated with a dial calibrated for the known expansion "peak" of each type of metal; an electric expander drive motor; and either a Model G-800 or G-1200, ball-bearing type, condenser and heat exchanger tube expander. When maximum torque is reached, the control cuts the power off automatically, the motor reverses, and the operator may then withdraw the tool and go on to the next tube-end. The control operates on 110 v., 60 cycle current, or it may be furnished for DC use. Airetool Mfg. Co.

11—Multiple Rotameter

The Brooks Multi-Tube rotameter can be built with two or more rotameter tubes in it for use in studying related flows. Standard "Full-View" rotameter end fittings are fastened to a metal back plate with dowel pins and cap screws. The front of the unit is shielded with a plastic window ¼-in. thick. Each tube with its fittings may be removed without disturbing any of the other parts. Brooks Rotameter Co.

12—Truck Pay-load Increased



Straddle truck extension shoes, which increase the possible length of palletized loads and eliminate the need for special large skids, have been developed by Superintendent Frank Edwards of the Pt. Molate Naval Fuel Annex of Richmond, Calif., for handling petroleum drums. The extensions bolt to the regular gripping shoes of the truck and may be mounted or dismounted by one man in 15 to 20 minutes, it is stated. As shown in the official Navy photograph, the shoes are installed on a Hyster "MH" truck, and are transporting 40 filled drums weighing about 10 tons. The pallets are 48 x 72 in., accommodating four drums on their sides, and were pre-aligned two high by a standard fork lift truck. Hyster Co.

13—Stainless Steel in Solution

Flakes of 18-8 stainless steel, Type 302, in a vehicle of vinyl copolymer resin material has been found to be a hard, tough, and durable protective coating with high corrosion resistance, suitable for refinery piping, headers, tanks, and the like. The paint, known as "Paraline 18-8" is said to be unaffected by aging, sunlight, petroleum hydrocarbons, fresh or salt water, alcohol. It is not recommended for aromatic or chlorinated hydrocarbons, ketones, and some esters. It can be applied by brush, spray, or dip. Color is blue-grey. Coverage is from 400 to 500 sq. ft./gal., per coat, with a thickness of one mil. Drying time, tack free, is 10 minutes. Complete cure is 24 to 30 hours after final coat. No primer is required. Heat resistance is up to 250° F. Barber-Webb Co., Inc.

Trade Literature

14—Valve Maintenance

Maintenance & Repair Manual, Nordstrom Valves, Bulletin V-206: 44 pages devoted to instructions on the proper care and operation of a line of plug valves; includes cutaway detailed drawings, assembly instructions, test and working pressure ratings, and a complete catalog section on valve parts. Nordstrom Valve Division, Rockwell Mfg. Co.

15—pH Instrumentation

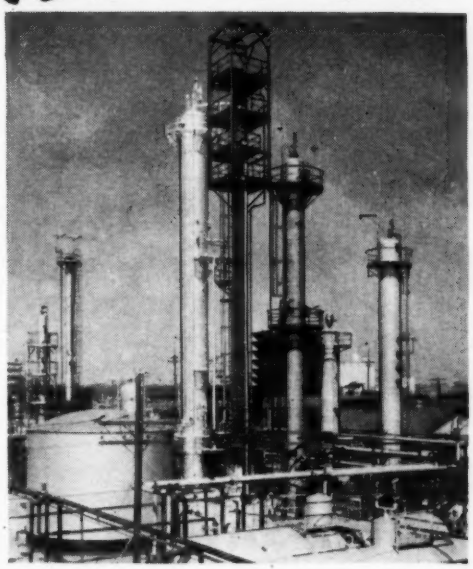
Foxboro pH Instruments, Bulletin 430: 16 pages explaining the measurement and control of acidity or alkalinity in processing operations, how it may be applied, and the kind of instrumentation employed. Foxboro Co.

16—Piping Assemblies

Crane Unit Fabrication; a four-page folder describing the advantages and economies of factory unit-fabrication of welded piping headers, assemblies, and valve groupings into one-piece, pre-tested units. Crane Co.

More "What's New!" Item, p. 822

ONE TOWER...
OR A COMPLETE REFINERY?



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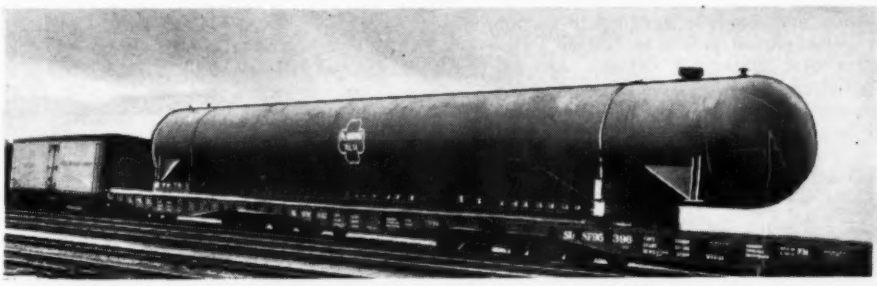

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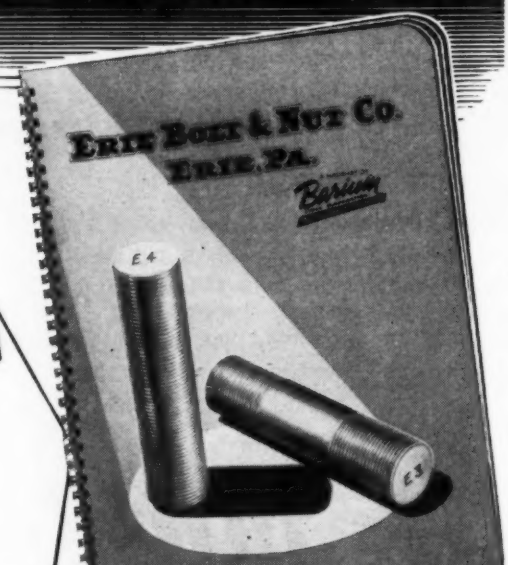

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FUEL OIL PUMPING and HEATING UNITS..

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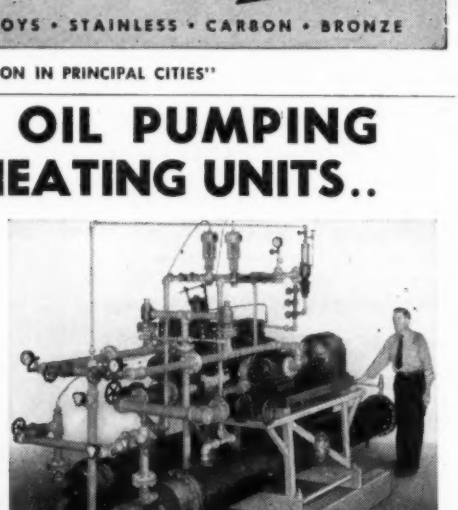

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INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

What's New!

17—Air Heaters

Peabody Direct Fired Air Heaters, Bulletin 600; a four-color, six-page bulletin illustrated with flow charts, cross section drawings, operating data, etc. explaining the operation and use of air furnaces, including their use in catalytic cracking units. Peabody Engrg. Corp.

18—Additive Materials

Crotonic Acid, recently made available in commercial quantities, is described in a new bulletin giving specifications, properties, uses, and a bibliography of technical literature. Resins obtained from the chemical find application in lube-oil additives, protective coatings, etc. It also is used in preparation of solvents, insecticides, etc. Tennessee Eastman Corp.

19—Aluminum Exchanger Tubes

Alcoa Aluminum Heat Exchanger Tubes: 24-page booklet describing aluminum alloy and aluminum clad tubes, effects of various chemicals, fluid flow characteristics, working pressures, estimating data, tensile properties, nominal compositons; with tables and charts. Aluminum Co. of America.

20—Compressor Piston Design

Operating Flexibility for Process Gas Compressors: a 5-page reprint of an article by W. R. Barrett, Phillips Petroleum Co., on a new clearance pocket piston for increasing flexibility of operations in gas compressors, and originally presented at December 10, 1948, meeting of Natural Gasoline Association of America. Clark Bros. Co., Inc.

21—Expansion Joint Design

Design Guide to Expansion Joint Selection and Application: a 28-page bulletin including tables on thermal expansion in piping, specifications of several lines of controlled and free-flexing expansion joints, a nomographic chart for obtaining line thrust due to internal pressures, and typical examples of installation problems. Chicago Metal Hose Corp.

22—Water Treatment Problems

Steam and Water Purity Indicator, Carryover and Condenser Leakage Alarm, Technical Bulletin 11-23-48 RCU: a six-page booklet covering the various problems encountered with steam and condensate purity, describing new test apparatus and including price list of equipment. E. F. Drew & Co., Inc.

23—Diaphragm Control Valves

Belfield Diaphragm Control Valves, Series 700, Bulletin 700-1: a 32-page booklet on a line of pilot piston control valves, air operated, in sizes up to 14-in.; including specifications, shipping weights, price lists, and charts of flow characteristics. Belfield Valve Division, Minneapolis-Honeywell Regulator Co.

24—Stainless Steel Valves

Cooper Alloy Comparison Chart, Stainless Steel 2-in. Gate Valves: one of a series of detailed engineering comparison charts to assist in the selection of stainless steel valves, presenting features of competitive valves. Cooper Alloy Foundry Co.

25—Industrial Alcohols

Alcohols, Solvents, and Other Chemicals by Publicker: 64 pages covering line of products including various alcohols, acetates, acetone, acetaldehyde, acetic, fusel oils, etc., giving information on export, methods of analysis, shipping containers, table of tank car volumes. Publicker Industries, Inc.

26—Thermocouple Manual

Wheelco Thermocouple Manual, Bulletin T/C 7: gives information on proper selection, installation, and testing methods, as well as current prices on thermocouples and accessories; includes temperature-millivolt curves, resistance tables, pipe and wire sizes, and lead wire conduit capacities. Wheelco Instruments Co.

27—Dryer Catalog

Kemp Dryers for Air, Gases and Liquids, Catalog D-27; 32 pages on basic principles of equipment for dynamic drying of air, many gases, and such liquids as gasoline, distillate fuel oils, freon, butane, etc.; includes cut-away views, drawings, selection charts, specifications. C. M. Kemp Mfg. Co., Inc.

28—Recording Viscometer

Norcross Bulletin V-1000A; covers the design and principle of operation of a new recording instrument for viscosity measurements of all solutions at atmospheric pressure, from the lightest, such as water, to almost any substance that will flow. Norcross Corp.

29—Blowers & Exhausters

Blowers and Exhausters, Centrifugal Type, Bulletin B-5: gives technical data and ordering information on a line of this equipment ranging from fractional to 250 hp. units, in capacities as high as 11,000 cfm., and available for poisonous or explosive gases with spark-proof materials and sealing gaskets. Allen Billmyre Division, Lamson Corp.

30—Wire-wound Concrete Tanks

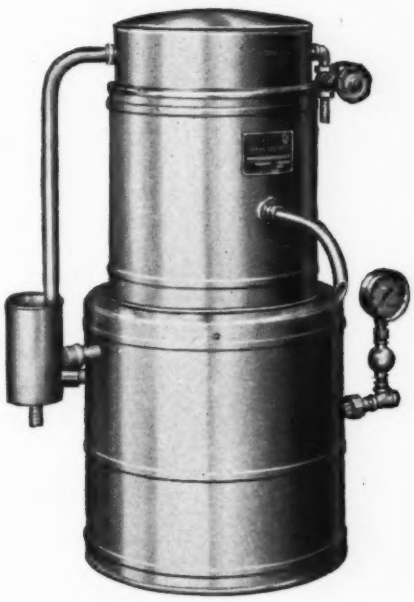
Preload Tanks; a 24-page, illustrated booklet discussing in detail the evolution, uses, design, and construction of wire-wound concrete storage tanks for petroleum, chemicals, water, and so on; including complete specifications for building these structures. The Preload Corp.

31—Rotameters

Recording and Controlling Rotameters; Bulletin 18-RC: cut-away views, sectional drawings, and functional diagrams aid in explaining the construction, operation, and application of this line of electronic and pneumatic flow instruments. Schutte & Koerting Co.

More "What's New!" Items, p. 824

Greatest Improvement in Water Stills in 25 Years



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32—Corrosion-resistant Alloys

Duriron and Durichlor, Bulletin 113: 12 pages on these high silicon iron alloys; mechanical and physical properties, nominal chemical composition, welding methods, handling and maintenance; including a table of resistance to common corrosive materials. The Duriron Co., Inc.

33—Fatty Acid Esters

Fatty Acid Esters; a set of data sheets in chart form, giving specifications and respective solubility in oils, solvents, and waxes of various molecular weight polyethylene glycol mono-and di-stearates, laurates, and oleates, and also various glycerol and glycol esters of fatty acids. W. C. Hardesty Co., Inc.

34—Sulfuric Acid Dilution

Karbate Sulphuric Acid Diluting Equipment, Catalog Sect. M-8806A; describes a complete system, made of impervious graphite, for efficient production of cool dilute acid from the required quantities of commercial strength acid and water, using forced convection cooling and counter-current flow in a closed system requiring no dilute acid pump. National Carbon Co.

35—Non-fouling Heat Exchangers

The G-R Type CW Tubeflo Section, Bulletin 1622: explains design of heat exchanger in which heavy, viscous, or sediment-bearing liquids are carried through without fouling; including a chart for solving mean temperature difference formulas. Griscom-Russell Co.

36—Electric De-salting

Petreco Electric De-salting; a 12-page booklet explaining the electrical method for de-salting crude oil, with charts showing operational effects on charge rate, furnace temperatures, pre-heater performance, and salt content of crude; including case histories. Petroleum Rectifying Co.

37—Directory of Consultants

Consulting Services, 1949, 12th Edition: 132-page book; a classified directory of consulting chemists and chemical engineers, indexed, listing all data available, including type of work handled, other activities, company officers, and description of staff. Association of Consulting Chemists and Chemical Engineers, Inc.

38—Flow Instruments

Materials of Construction for Flowrator Instruments, Catalog Section 97: a tabulation of suggested corrosion-resistant materials of construction and for packing for use with over 300 industrial liquids and gases. Fischer and Porter Co.

For Your Convenience

Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing page 817. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.

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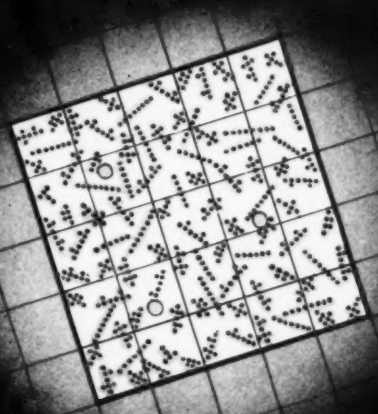

An ultra-ultra-microscope might show the above view of an untreated gasoline. It would disclose the presence of those **THREE YELLOW MERCAPTAN MOLECULES.** It is an established fact, that these mercaptans destroy the effectiveness of Tetra-ethyl-lead. The Tannin-Solutizer process removes them and for the same Octane of the finished gasoline, T. E. L. requirements may be cut-in-half.

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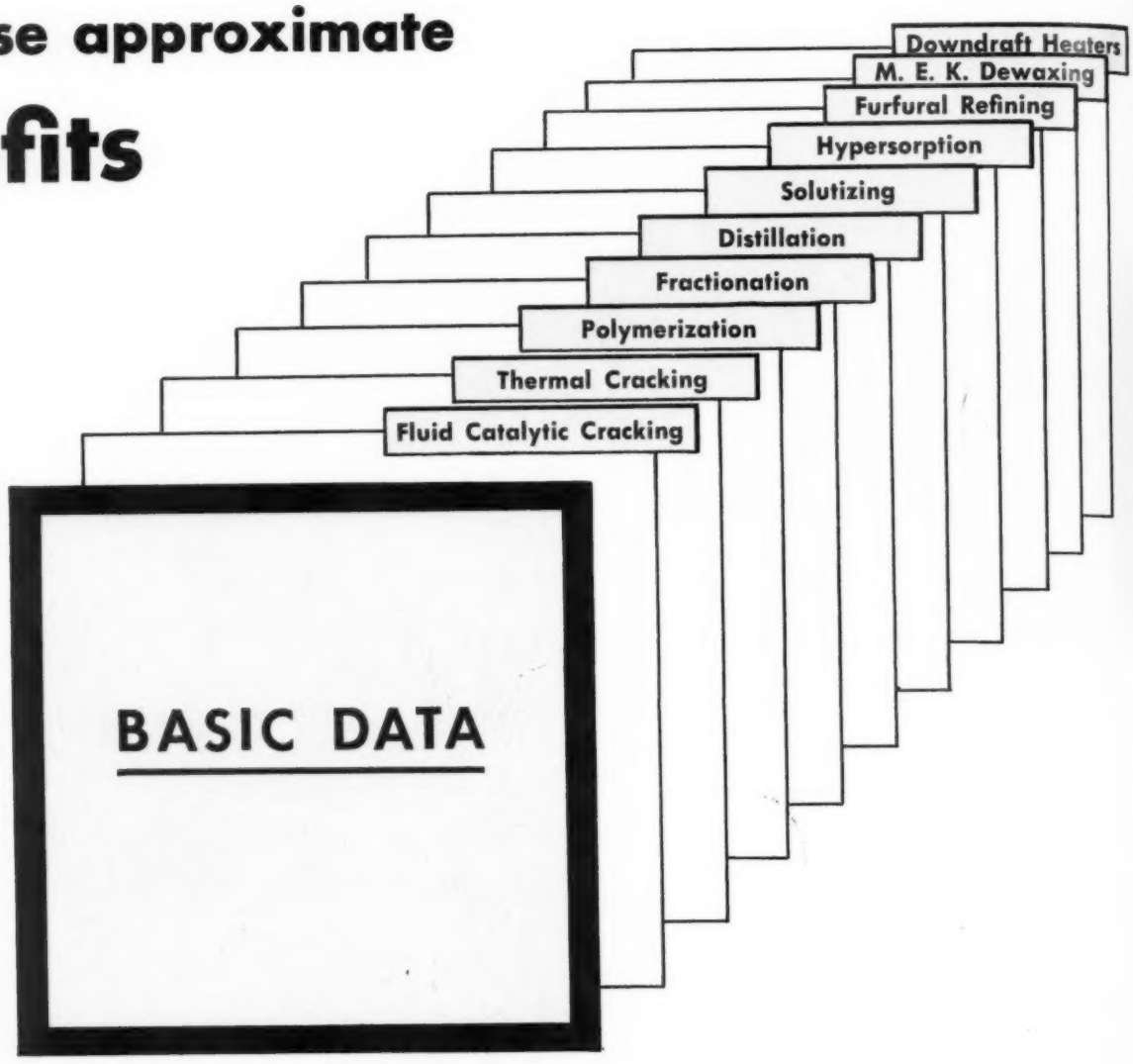

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PHILADELPHIA, 2	Packard Building
PITTSBURGH, 22	Oliver Building
SAN FRANCISCO, 4	206 Sansome Street
WASHINGTON 5, D. C.	Tower Building

NEWS OF

Manufacturers—Suppliers—Engineering Firms

Serving the Petroleum Processing Industry

Dresser Industries Opens Gulf Coast Division Service Depot and Offices

New Gulf Coast headquarters for Dresser Industries in Houston

Dresser Industries, Inc., celebrated the official opening of its new Gulf Coast Division offices and service depot at 1619 Ovid St., Houston, with an open house party May 13, attended by more than 600 guests in the Southwest oil and gas industry and a number of Dresser officials.

The building contains 6000 sq. ft. of air-conditioned office space and 14,000 sq. ft. of warehouse facilities. It will serve as Gulf Coast headquarters for Dresser and five of its oil and gas equipment manufacturing subsidiaries, including Clark Bros. Inc., and Pacific Pumps, Inc. Clark will maintain a complete service and parts department. Pacific, however, will not stock pumps or parts at the new address, this serving as a Gulf Coast office only. Pacific will continue to distribute through Republic Supply Co. in this area. The Dresser Manufacturing Division also will not move over to the new building, but will continue to occupy its present location at 1121 Rothwell St., Houston.

J-M Dedicates Research Center

Research projects at the new Johns-Manville Research Center in New Jersey, which was formally dedicated May 24, include several dealing with materials used by the petroleum industry. Among them are the development of improved low-temperature insulation, particularly for tonnage oxygen plants; new high-temperature refractories; better fire bricks, specifically for oil-burning domestic heating units; and many others.

The new center, situated on a 93-acre tract on the north side of the Raritan River about ¾ miles from the main J-M plant at Manville, N. J., comprises four main buildings. A feature of the 574 x 138 ft. Product Development Building is the experimental manufacturing section.

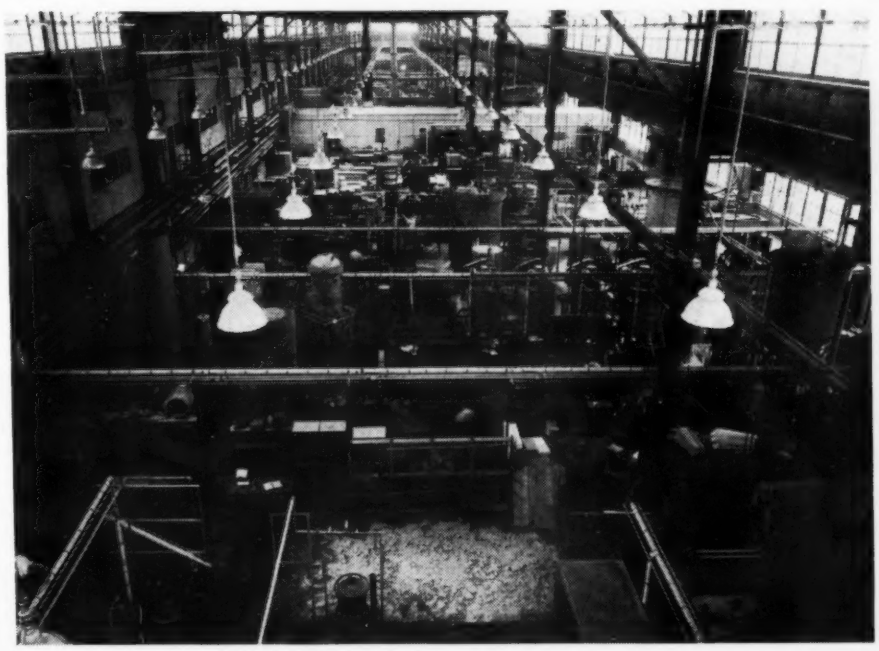
Here in a single room, 100 ft. wide by 574 ft. long, and under one long, continuous, high-bay monitor, are 10 pilot plants. Equipment includes a miniature manufacturing plant for asbestos fibre, a Transite pipe machine, magnesia insulation machine, and other units. Sections in the area have not been separated by walls, although there are two totally-enclosed test rooms built on the floor. Because much of the work deals with wet processes, drainage trenches have been installed 22 ft. apart on centers and extending 90 ft. across the building to a larger main collecting trench along one outside wall.

Dennis to Engineer Refineries

E. L. Dennis Engrg. Co., 715 Camp St., New Orleans 12, La., has recently expanded its facilities to include complete engineering service to refineries, natural gasoline plants, chemical plants, and allied industries. The program is being consolidated under the Process Division of the company and will be headed up by Lawrence E. Skelly, formerly with Stone & Webster Engrg. Corp., Process Division.

Mr. Skelly

A graduate of Toronto University in 1936, Mr. Skelly was for several



Efficient natural and artificial illumination, room for expansion of activities feature huge pilot plant building in new J-M research center

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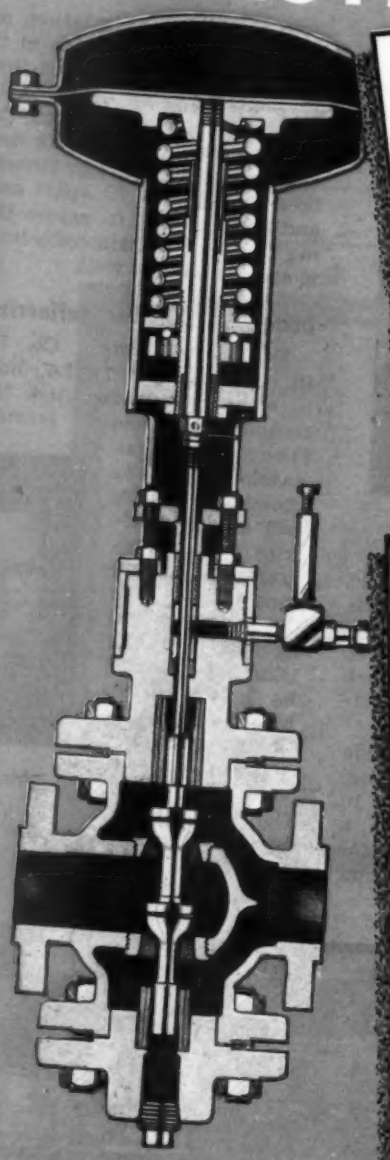

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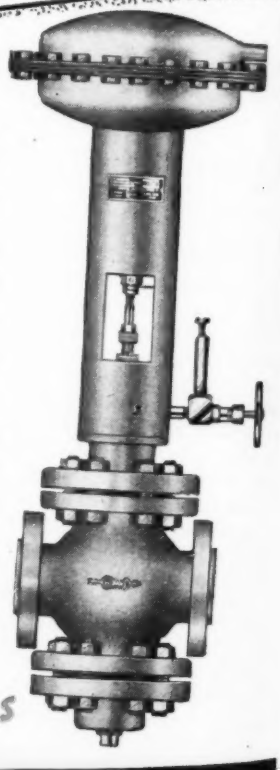
These Standard Control Valves are designed for use with air operated instruments for control of pressure, temperature, liquid level, rate of flow, humidity or pH. They can be applied with equal efficiency on air, water, steam, oil or gas service and are available in sizes from ½" to 12".



The ALLSTEEL Superstructure is fabricated from 3/16" steel stampings. Oilite Bearings eliminate spring stem friction. Stainless steel spring stem standard. Packing box bolted on all size valves. Bonnets and blind heads are forged fabricated. Bonnet will support ALLSTEEL Superstructure if installed horizontally. They are through-bolted for greater strength and also to provide simplicity of field reversal. Valve bodies have ASA Standard Face to Face dimensions. All valve plugs are top and bottom guided in hardened stainless steel bushings. Valve action reversible in the field, requiring no additional parts.

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In Canada, Railway & Power Engineering Corporation, Ltd.

years prior to the war active in designing heat transfer equipment for gas, gasoline, and synthetic rubber plants. In that capacity he developed several phases ot cooling application for recycling and gasoline plant service.

Bethlehem Supply Co. Promotions

Three promotions at Bethlehem Supply Co. have been announced by I. C. Smith, general manager of sales. W. F. Taylor becomes manager of refinery sales July 16, succeeding T. B. Leech, who is resigning to join Petro-Chem Development Co. R. M. Berman has been transferred from Corpus Christi, Texas, to the Tulsa main offices as special representative in the refinery sales department, handling Petro-Chem Iso-Flow products. Luther A. Myers, formerly at the Houston sales office, is taking over the past duties of Mr. Taylor. He will call on the refining industry in Chicago, Tulsa, Omaha, Kansas City, and Bartlesville.

Mr. Leech will continue to reside in Tulsa and will be available for assistance in the sale of Petro-Chem products.

Oakite Names Carter President

John A. Carter has been elected president of Oakite Products, Inc., succeeding D. C. Ball, founder and first president of the firm, who was named Chairman of the Board. The new chief executive has been associated with Oakite for 34 years, serving recently as assistant to the president, and since December, 1947, as general manager.

David S. Ball, former vice president, was elected to the newly created office of first vice president. The following men were re-elected: H. Liggett Gray, vice president; James Beckett, treasurer; and David A. Hearn, secretary.

Cyanamid Co. Men Honored

William B. Bell, president, American Cyanamid Co., received the honorary degree of Doctor of Science, June 13, from the Philadelphia College of Pharmacy and Science, in recognition for his services in the field of public health and in the stimulation of pharmaceutical research.

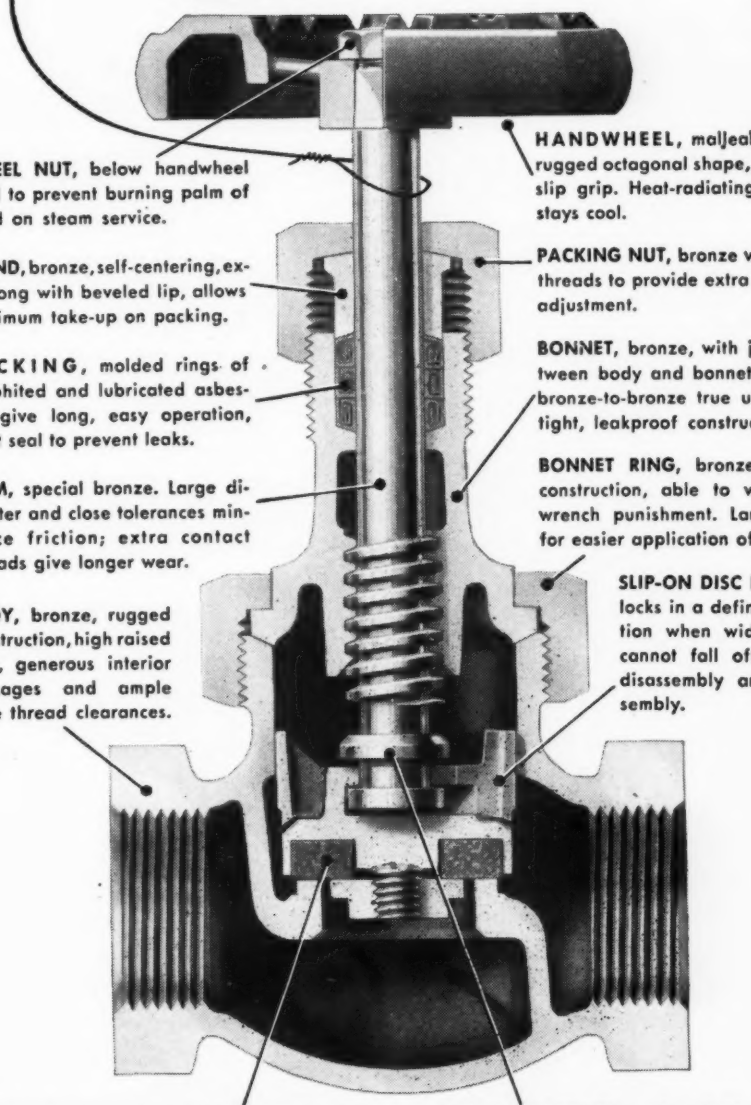
George W. Russell, assistant sales manager of the company's industrial chemicals division, was elected president of the Chemical Market Research Association at its annual business meeting in New York, June 9.

Marley Starts Louisville Plant

Production has started at the new plant in Louisville, Ky., of Marley Co., Inc., manufacturers of water cooling towers, nozzles, and dry surface cool-

Here's WHAT makes this KENNEDY VALVE Better . . . . and WHY!

KENNEDY HEAVY BRONZE GLOBE VALVE (FIG. 89) recommended for services up to 150 pounds steam or 250 pounds water, oil, air or gas. ¼" to 3" sizes available.



WHEEL NUT, below handwheel level to prevent burning palm of hand on steam service.

GLAND, bronze, self-centering, extra long with beveled lip, allows maximum take-up on packing.

PACKING, molded rings of graphited and lubricated asbestos give long, easy operation, tight seal to prevent leaks.

STEM, special bronze. Large diameter and close tolerances minimize friction; extra contact threads give longer wear.

BODY, bronze, rugged construction, high raised seat, generous interior passages and ample pipe thread clearances.

HANDWHEEL, malleable iron, rugged octagonal shape, for non-slip grip. Heat-radiating design stays cool.

PACKING NUT, bronze with long threads to provide extra packing adjustment.

BONNET, bronze, with joint between body and bonnet making bronze-to-bronze true union for tight, leakproof construction.

BONNET RING, bronze, heavy construction, able to withstand wrench punishment. Large flats for easier application of wrench.

SLIP-ON DISC HOLDER, locks in a definite position when wide open, cannot fall off during disassembly and reassembly.

RENEWABLE COMPOSITION DISC, provides perfect seating; asbestos for steam service and special types for various services and temperatures.

BEVELED SHOULDER, makes tight joint with conical seat on underside of bonnet when valve is wide open, for repacking under pressure.

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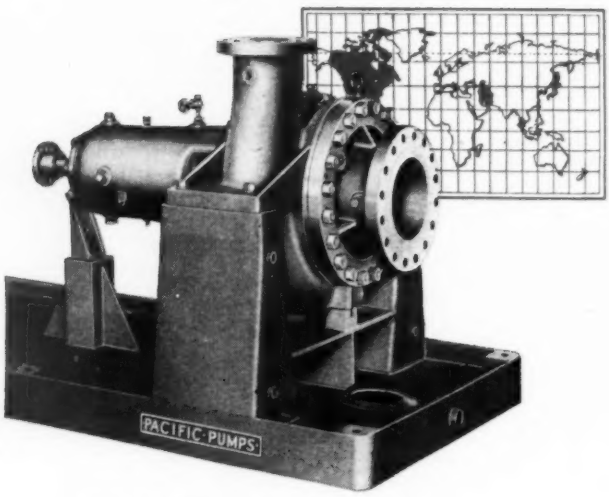

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ers. C. W. Zimmerman is plant manager. The plant primarily will fabricate metal for Marley products, but also will assemble some of the smaller units. Several models of nozzles, towers, and coolers will be carried in stock.

Clark Promotes Van Campen

Three men with Dresser Industries companies have figured in recent changes. A. G. Van Campen, formerly sales engineer in the New York office, has been promoted to District Manager of the Chicago office of Clark Bros. Inc., at 122 So. Michigan Ave. With Clark since 1936, his background covers all phases of gas engine driven reciprocating and centrifugal compressor work.

Mr. Van Campen

Mr. McDonald

A. R. Hauser, who has been representing both Clark and Pacific Pumps, Inc., in the Chicago area, will now devote all his time to Pacific Pumps. R. C. McDonald has been transferred from Pacific Pumps to Clark, taking over the vacancy left by Mr. Van Campen at New York. Before joining the organization in 1946, Mr. McDonald was associated with Foster Wheeler in charge of application engineering for the petroleum refining division. That work involved application of pumps, and compressors, (centrifugal and reciprocating), motors and turbines.

Branches, Distributors

W. M. Barnes Co., refinery and railroad construction engineers of Los Angeles, has opened two new branch offices. One is in Edmonton, Alberta, at 10053 Jasper Ave., and will be managed by Fred J. Underwood. Mr. Underwood was project manager in charge of erection of the Imperial Oil Co.'s Edmonton refinery, recently completed by the Barnes organization. The second office is at 654 Madison Ave., New York City, and will be under the direction of H. W. Nelson, recently named vice president of the Barnes company.

Ansul Chemical Co., Marinette, Wis., will now offer sales and service for its Dry Chemical Fire Extinguishers in the Pacific Coast states formerly

served by **Snowden Chemical Co.**, of Modesto, Calif. Ansul has opened offices in Los Angeles, Fresno, and Oakland. Robert E. Sexmith has been named West Coast Manager, Fire Extinguisher Division, with offices in Los Angeles.

Tube-Turns, Inc., Los Angeles branch office has been moved to Suite 447 in the General Petroleum Bldg., 612 South Flower St. The new telephone number is Madison 6-3219. The office formerly was located at 1489 West Washington Blvd.

Koch Engineering Co. has appointed Perry Kilsby, Inc., 3311 East Slanson, Los Angeles, as Pacific Coast representatives for Koch Kaskade Fractionating Trays.

Other Personnel Changes

National Foam System, Inc.—William H. McGunagle has been made sales representative in the northern part of Ohio, with headquarters in Cleveland.

National Supply Co.—W. R. Patterson has been appointed general superintendent of the steel department at the Torrance, Calif., plant. He will continue also in his present capacity as chief plant metallurgist, a position he has held since 1943.

Dearborn Chemical Co.—Edward S. Bus has been added to the sales staff, and will take over the Washington-Oregon territory now covered by Colin Fryer, who is being transferred to the company's Honolulu office. Mr. Bus will make his headquarters in Seattle.

Hooker Electrochemical Co.—Edwin R. Bartlett, president, was elected a board member of the National Industrial Conference Board for the coming year at the Board's 33rd annual meeting, May 25, in New York City.

Koch Engineering Co.—John Hufnagel has been appointed manager of the Kaskade Tray Division, with headquarters in Wichita, Kans. He was formerly with Hydrocarbon Research, New York.

Lukens Steel Co.—Darwin S. Wolcott, with the firm 24 years in the vice presidency since 1928, has retired from active service, effective July 9. His activities have included administrative and sales work, with particular attention to development of the company's foreign conversion and to clad steels. Samuel Wit, who has been a sales engineer with Lukenweld, has been named district manager of sales of Lukens Chicago office, replacing J. H. Faunce, Jr., who has assumed other duties with Lukens.

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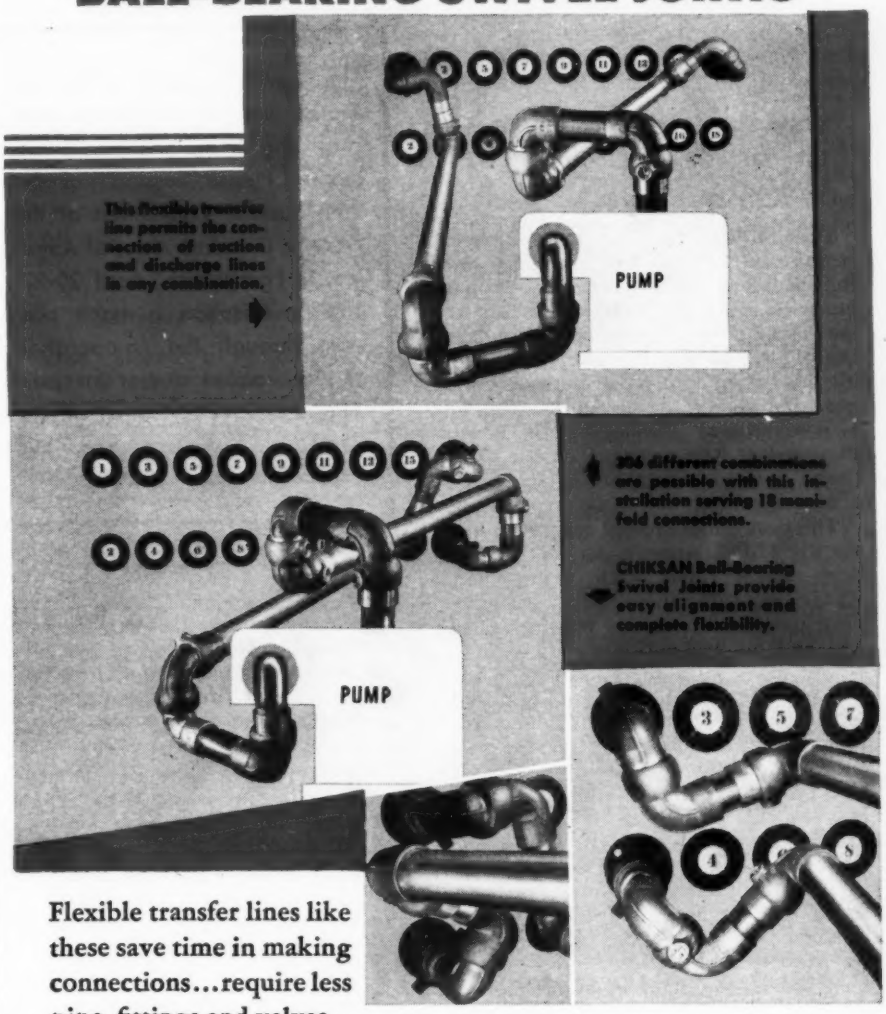
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BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

Gasoline and Cycling Plant Operation

Conducted by DAVE THORNTON

The Questions and Answers presented here are from a wire recording of the popular "Information Please Session" of the 28th Annual Convention of the Natural Gasoline Assn. of America, in Fort Worth, April 20-22. Their publication is made possible through the co-operation of the various authorities participating, W. F. Lowe, NGAA Secretary, and J. E. Pew, Sun Oil Co., session moderator.

What are the possibilities for underground storage of LP-Gas?

Possibilities for the underground storage of LP-Gas are excellent, but the problem of finding the proper place is more difficult. It seems to me that in the larger areas, where there may be several plants producing between them a considerable quantity of LPG, this might well be a co-operative development. I am thinking at the moment of the Carthage Field, where there is apt to be a large volume of LPG produced.

The best underground reservoirs for storing LPG appear to be rather deep zones filled with water—salt water sands, for instance, which have been discovered on the way down to gas and oil production.

The most suitable type of zone for this purpose should be an anticlinal formation. If there is sufficient information available from oil and gas development in the area to permit locating the crest of the structure and the salt water sand exists at the crest, the reservoir will be ideal. This is because it will be deep enough to permit liquid phase injection and there will be no mixing with water because of the specific gravity differential.

A special problem must be met if the use of shallow sands (2000 to 3000 ft. deep) is attempted in an area where there are numerous wells producing from deeper formations. The deep wells must be properly cemented from below the formation to be used for LPG storage to the cellar of the well. Otherwise, all or most of the stored product may be lost around the casings of the deep wells. The situation is no different in the event it is desired to use very shallow sands unless the second casing string likewise is cemented from the well cellar to below the desired formation.

It seems to me another suitable reservoir would be some of the salt mine cavities. They are rather deep, definite in dimensions and could be readily converted into liquid reservoirs. Again it appears such a reservoir would be too large for an individual company.

There is one other rather serious problem, more apt to be encountered in California than the Mid-Continent. This is the possibility of washing down bitumens and plugging the formation when LPG injection commences. The operation might start satisfactorily and then the formation would suddenly plug up to the extent that no more fluid would enter. Such conditions call for the strictest kind of cleaning before injection of LPG is started.

Using either a salt mine cavity or a sub-surface reservoir, the problem indicates that some sort of co-operative development will be needed to secure adequate storage unless the market situation levels down to a smaller summer-winter supply ratio. Underground storage already is being practiced in some cases to a small degree.

It may be that suitable reservoirs can be found in many areas. We believe that a great many of them exist in numerous oil fields, but to find them will call for a thorough review of many electric logs. We believe many more of them will be discovered and used than now are known; at present they just have not been considered for this purpose. However, we still favor the salt water sands, the crests of which will make excellent natural storage places.—E. O. Bennett, Consulting Engineer, Houston.

* * *

Carter has been doing this at Fittstown for a number of years. Completed oil wells were used there fairly successfully and cumulative withdrawals have reached as high as 70% of cumulative injections.

In certain other instances, the wells selected were failures. They were exhausted oil sands. There was quite a problem in withdrawing the butane. This usually started in the liquid phase and perhaps flowing, later going to sucker rod pumping and finally to gas phase under vacuum. This identical cycle would be repeated after the storage quantity had been built up by further injection.

The big problem seems to be to get wells where the reservoir conditions will contain the injected butane. In another case the well used for propane worked successfully, although I would say that the percentage of "successful" wells out of those tried was of the order of 25% to 30%. I do not mean to imply that a large number of wells were tried, but probably there were about two out of six or seven which proved successful.—Unidentified member of the audience.

* * *

These experiences seem about the same as those we have had in California, where we are very much interested in the storage of LPG. About two years ago we started injecting normal butane into a well in Kettleman Hills.

Of course, when the LPG man or a natural gasoline man wants to do that he opens discussion with the production department on the possibility of bitumen deposits. They are sometimes afraid it might affect oil production. But in one experiment, which I consider very successful, we did recover about 50% of the butane in the liquid state. Last summer we tried injection of LPG at another level, with an experience of 30% recovery. However, with most of that coming out in the vapor state, it put excessive load on our compression facilities so we cut it down.

I think there are some other places where it is entirely feasible to do this and I believe it is our solution to this excess of propane, representing the big difference between the summer and winter demand load.—T. L. Taggart, Manager, Natural Gasoline Dept., Standard Oil Co. of Calif., San Francisco. (Contributed discussion from the floor.)

What is the status of the underground storage project which the Chicago Corporation now has under way?

All I can say now (April 22) is that we made some studies of a sand

reservoir in the Carthage Field area which is about 3100 ft. deep and contains salt water. Through the isobars of the sand area we think that it is a closed reservoir in the top with a salt water drive at the lower section of the sand. We hope—and I want to emphasize that word "hope"—to be able to put propane in the salt water, force the water back, maintain the propane at the top of the water interface and use old Mother Earth as the top of the reservoir that will hold the propane in place.

We have appropriated $175,000 to make the experiment and it is nothing more than an experiment. At the present time the first well has been drilled, the salt water sand tested, and casing has been set. The pump to inject the propane is set and the line will be completed sometime this week.—C. R. Williams, vice-president, The Chicago Corporation, Corpus Christi.

(Editor's Note: Mr. Williams was not a member of the panel of experts, but was asked this question in connection with other questions on the subject. Early in June, Mr. Williams advised that the well up to that time had received 4,769 barrels of propane, but that no attempt had been made to back-flow the well to determine whether or not the propane can be recovered. Such tests will be made when approximately 10,000 barrels have been injected. Following is tabulated the injection pressures required to return bearing volumes of propane to the formation:

Discharge Pressure	G.P.M.
1,350 lbs.	23
1,475 lbs.	38
1,575 lbs.	38
1,800 lbs.	47
1,875 lbs.	56

What is the most promising method of removing nitrogen from gas? What is the current stage of perfection and what will it cost when reasonably well perfected?

We have done quite a bit of work on the nitrogen removal problem. Up to now our feeling is that the scheme of liquefying all or a large part of the gas, followed by fractional distillation in a column, appears the most practical; that is, it at least uses process steps which are known to work. This is not intended as derogatory to the Hypersorption process at all since I am personally very much interested in that as a possibility, too.

With very rough figures, so far it appears that Hypersorption probably will cost more and have a higher fuel consumption than the liquefaction-fractionation technique. Of course this is a serious objection.

In the last eight months we have had four to five men working continuously on calculations, trying out various schemes based on the liquefaction-fractionation technique. The schemes differ primarily in the completeness of nitrogen removal. If one goes whole-hog and liquefies *all* the gas, fractionates it and removes substantially all the nitrogen from the finished product, that is one scheme. Then, there are various stopping points, leading to cheaper plants, in the range between total nitrogen removal and doing nothing to the gas at all.

Economic Middleground

What seems to be the middle ground in terms of an economic answer, based on assumed conditions, yields a gas having about 1% to 1.5% nitrogen in the treated gas when the initial untreated gas ranges in nitrogen content between 17 to 28%. Considering the whole plant, from the gas coming in to the point where it is delivered to the pipe line, the price will be within shooting distance of $100,000 per 1000 Mcf. In other words, a plant handling 100,000 Mcf of gas per day will cost within striking distance of $10,000,000. The actual cost, of course, will depend on what kind of gas is being dealt with but, so far, the cases we have been working out are within the bracket of $100,000 to $125,000 per 1000 Mcf per day.—Henry Wade, Consultant, Stearns-Roger Mfg. Co., Denver.

How can you purge a tank which has contained LP-Gas?

The safest and most positive way to purge a tank which has contained uncontaminated LP-Gas, in my opinion, is with water—cold or hot. This is based wholly on the fact that the product has a boiling point below 32° F. The water positively will displace the gas, pushing it out the top of the tank where it can be disposed of safely.

The normal safe method is to burn it. When water comes through the burner the tank may be considered gas-free.

It is my understanding the conventional procedure has been to steam the tank. However, I have encountered many cases where explosions have occurred even after steaming has gone on for a considerable length of time whereas, with water, I have never had any trouble whatsoever.

As a precautionary measure, the atmosphere in the tank should be tested after the water has been displaced. An additional precaution suggested is to use a back flow check valve in the filling line, in the event that pressure might drop, a line-failure occur, or some other unexpected happening develop. If any one of these accidents should happen before purging is completed and no backflow check is used, the reversal of flow might draw enough air into the tank to form an explosive mixture.—J. K. Smith, Field Engineer, LP-Gas Assn., Inc., Chicago.

What is the Commission's attitude with regard to the shutting in of oil fields when the producers do not wish to be forced to sell their gas on a long-term price contract to a gas pipeline?

The Commission's responsibility is to prevent waste. At no time has it ever said to producers they must sell their gas. The Commission simply says: "Don't produce the oil until you are ready to utilize the gas that you produce with the oil." In this stand we were upheld by the state Supreme Court.

However, I am enough of a practical man to recognize that in most cases the solution to our requirement that waste be stopped is to market the gas. We are ordering producers, in effect, to market their gas.

There have been complaints that we are putting producers over a barrel, so to speak, in negotiations with gas purchasers. That is not the intention; but when you are dealing with price and other contract terms, it is a field in which the Commission cannot enter. However, there does seem some possibility that if there is much hesitancy on the part of gas purchasers to take this flare gas, the Commission probably would start cutting back on other supplies of gas until the purchasers wanted the casinghead gas. If there is a given oil field which has no market for its oil, we do not require the oil pipelines to purchase from this field; but we consider this pretty strong proof that we are producing more oil than the total market demand.

Allocation Predicted

Consequently, if flare gas is tendered to pipe lines under the conditions under which they normally take it and there are no takers, then that is proper proof that we are producing on a statewide basis gas in excess of demand. Then, I would anticipate the Commission would start cutting back. I predict ultimately there will be allocation between producers in given fields and between different fields and the total production of all the fields will be regulated to the total demand for gas.—W. J. Murray, chairman Texas Railroad Commission, Austin.

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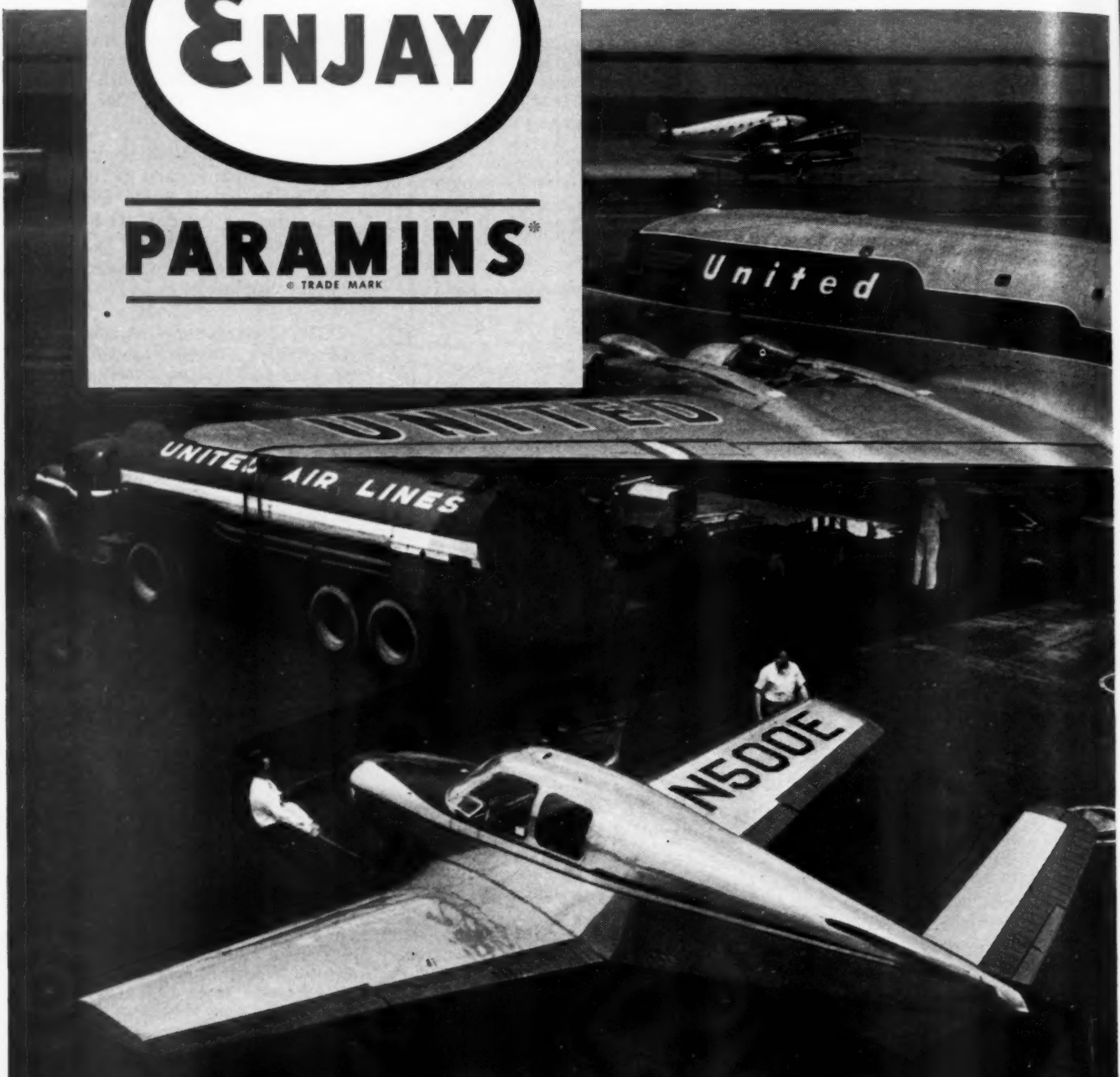

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Personals

Stanley Learned has been elected a director of Phillips Petroleum Co. and a member of the executive committee. He fills the vacancy on the Board created by the recent death of **Ch. A. Lemp,** of St. Louis, and the vacancy on the executive committee created by the recent retirement of **Frank Phillips.** Mr. Learned is chairman of the operating committee and during his 25 years with the company has served as chief engineer, superintendent of products pipe lines and in other capacities.

* * *

T. G. Hughes was elected executive vice president of Oronite Chemical Co., chemical products subsidiary of Standard Oil Co. of California, and

Mr. Hughes

Mr. Anthony

B. W. Anthony a director and secretary-treasurer. Mr. Hughes went to work for Standard in 1926 and has been with Oronite since its formation in 1943. Mr. Anthony was transferred from California Spray Chemical Corp., another subsidiary, where he was a vice president.

* * *

Clayton M. Beamer is manager of alcohol and chemical sales of Enjay Co., Inc., chemical products marketing affiliate of Esso Standard Oil Co. After service with the chemical products department of Esso, he was transferred to Enjay in 1948 as technical service coordinator of alcohols and chemicals.

* * *

Clyde H. Britten, vice president in charge of manufacturing, Lubrizol Corp., has been elected a director. With Lubrizol for the past three years, he was formerly with Shell Oil Co. as manager of product applications and development, in San Francisco.

* * *

C. F. Smith, superintendent of the light oils division of the Whiting refinery of Standard Oil Co. (Indiana) has been promoted to assistant general superintendent of the refinery. He received engineering degrees from the Universities of Utah and Illinois and joined the company in 1928, in the engineering department at Whiting. After serving at the Casper, Wyo., refinery from 1933 to 1938 he returned to Whiting and in 1942 was made assistant general foreman of the pressure stills department. He became general foreman of the catalytic cracking department in 1946, assistant superintendent of the light oils division in 1947, and superintendent in 1948.

C. E. Evans, assistant superintendent of the light oils division at Indiana Standard's Whiting refinery, becomes superintendent, succeeding Mr. Smith. A graduate of University of Iowa, Mr. Evans joined Standard in 1937 as a chemical engineer in the Whiting research department and in 1942 was transferred to the manufacturing department as assistant general foreman of the pressure stills department. He was made general foreman of pressure stills in 1946.

Dr. Ford H. Blunck, general foreman of the pressure stills department in the light oils division, succeeds Mr. Evans as assistant superintendent of the light oils division. He is a graduate of the University of Illinois and received a doctor's degree from Northwestern. He joined the company in 1936 as a research chemist. In 1945 he was transferred to the manufacturing department as acting assistant general foreman of the crude stills department. He became foreman and later foreman of the pressure stills. He served in chemical warfare service during the war.

* * *

W. T. Cravens has been appointed assistant general superintendent of the refining division of Cities Service Oil Co. (Del.), and will make his home in Bartlesville. With the Cities Service companies for the past 12 years, Mr. Craven has worked at Shreveport, Lake Charles, and recently in the New York office for Petroleum Advisors, Inc. He is a graduate in chemical engineering of the University of Arkansas.

* * *

Roy J. Diwoky, formerly of Standard Oil Co. (Indiana), has been made executive assistant to the president of Pan American Petroleum Corp. and will serve as a director of that corporation. He will be located at New Orleans. He holds degrees from the University of Iowa in chemical engineering and chemistry and became associated with the Indiana Standard in 1935. After five years in the research department, he was transferred to the manufacturing department, in 1948 being made assistant general superintendent of the Whiting refinery.

* * *

F. J. Schempf is head of the Texas-Louisiana Gulf Coast Division, Stanolind Oil and Gas Co., succeeding **R. E. Nelson, Jr.,** who was made assistant to the president of Stanolind Pipe Line Co., at Tulsa. **C. T. Jones** is manager of the Central Division of Stanolind Oil and Gas, at Oklahoma City, succeeding Mr. Schempf.

* * *

Wilber Otis Teeters is in the Jersey City laboratory of the Petroleum and Chemical Research Dept. of the M. W. Kellogg Co. He is associated with product development activities in the petroleum and chemical fields.

* * *

Mr. Burn

James L. Burn, III, Technical Service Dept., Socony - Vacuum Laboratories, Brooklyn, is the recipient of the company's 1949 incentive fellowship award for advanced study for a doctor's degree. He is planning to enroll in Columbia. A native of Tennessee, Burn received a M.S. degree from the University of Tennessee in 1944 and joined Socony-Vacuum in 1945.

Under the terms of the award, he will receive his full salary during the period necessary to earn his degree. He was selected from candidates in Technical Service, Research and Development and Field Research departments. One recipient is selected each year. Candidates are required to have a bachelor's degree and to have been employed by the company for at least two years. No restrictions are placed on recipients as to future employment nor as to publication of results of their investigations.

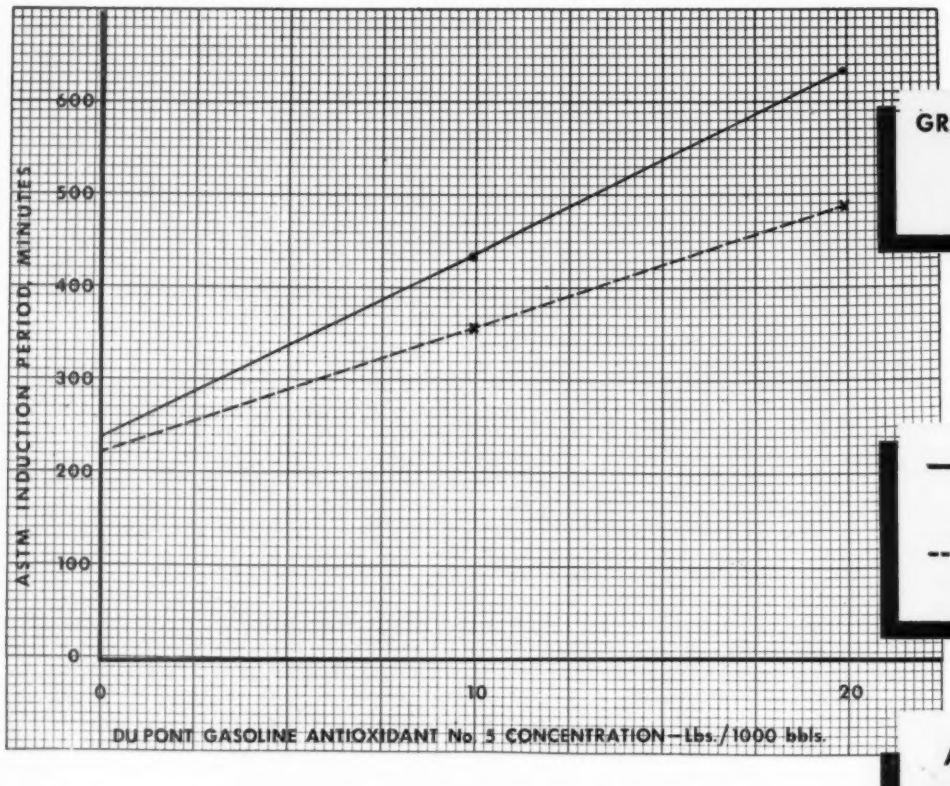
* * *

Lawrence R. Sperberg has been appointed manager of market research evaluation in the Philblack sales division of Phillips Chemical Co., subsidiary of Phillips Petroleum Co. He has been manager of the research evaluation and testing sections of the chemical division in Phillips Research

How one refiner*

Cut Gasoline Antioxidant Treating Costs 32%

with Du Pont Metal Deactivator



GRAPH SHOWING ANTIOXIDANT and METAL DEACTIVATOR RESPONSE

—●— Du Pont Gasoline Antioxidant No. 5 plus .25 lbs. per 1000 bbls. Du Pont Metal Deactivator

--------x Du Pont Gasoline Antioxidant No. 5

Antioxidant requirements for 1000 barrels of gasoline to meet 400 minute induction period

Du Pont Gasoline Antioxidant No. 5	13.5 lbs.
Du Pont Gasoline Antioxidant No. 5 plus 0.25 lbs. of Metal Deactivator per 1000 bbls.	8.3 lbs.
Net saving in cost through use of Du Pont Metal Deactivator	32%

This large refiner had been experiencing excessive gum formation in storage tanks. Ordinary analytical methods failed to show the presence of copper, but induction period tests demonstrated that copper was actually present in concentrations of less than 0.2 parts per million.

The use of Du Pont Metal Deactivator eliminated further trouble. The accompanying graph shows how with a Metal Deactivator concentration of only .25 lbs./1000 bbls. of gasoline it was possible to obtain a 400 minute induction period using 8.3 lbs. of antioxidant/1000 bbls. instead of 13.5 lbs./1000 bbls. without the use of Metal Deactivator—a total saving in treating costs of 32%.

Where copper is present, use Du Pont Metal Deactivator, the additive used by many refiners for years to economically control copper activity. For further information ask your Petroleum Chemicals representative or write the nearest District Office.

** Actual case taken from our files*

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District Laboratories: Wilmington, Del.; Chicago, Ill.; Tulsa, Okla.; Houston, Texas; El Monte, Calif.

department, where he has been associated with carbon black and synthetic rubber evaluation work and with the development of Philblack A and Philblack O. He graduated from Hillsdale College in 1934 with a B. S. degree in chemistry, and received his M. S. a year later at the University of Michigan. He joined Phillips research department in 1940.

* * *

Dr. Max H. Thornton has been appointed chairman of the chemical research division at Midwest Research Institute, Kansas City. He has been with the Institute since its organization in 1945. He received his Ph. D. at Purdue University, where he was an assistant professor.

* * *

G. F. Moore has been made division gas superintendent for Stanolind Oil and Gas Co., at Casper, Wyo. He will be responsible for the technical phase of the operation of Stanolind's natural gasoline, cycling and pressure maintenance plants in the division, as well as for the sale of products from these plants. Under his supervision will be the Elk Basin gasoline plant at Elk Basin and the Salt Creek gasoline plant at Midwest, Wyo. Before moving to Casper he was in the company's manufacturing department in Tulsa. He holds an engineering degree from the University of Delaware.

* * *

G. R. Kinter has been appointed a vice president of Tide Water Associated Oil Co. A resident of Tulsa he entered the company's employ as a refinery chemist in 1921 and has been vice president of the subsidiary Tidal Pipe Line Co. since 1934. He has been manager of the Mid-Continent Division's manufacturing department since 1937.

* * *

Carl Schweickert has left the Attapulgus division of Atlantic Refining Co. to accept a position as research engineer at Battelle Memorial Institute, Columbus, Ohio.

* * *

Luis Herrera has been appointed assistant to the president, Mene Grande Oil Co., Venezuela. Born in Caracas in 1906, Mr. Herrera received a degree in civil engineering at the Central University of Venezuela in 1929 and a year later entered the service of Paraguana Petroleum Corp. From 1931 to 1946, he served the government of Venezuela in various posts concerned with the petroleum refining industry. He resigned from these duties in early 1946 to join Mene Grande as executive assistant, which position he held until his recent promotion in May.

* * *

Dr. Gustav Egloff, Universal Oil Products Co., Chicago, has been made an Honorary Member of the American Institute of Chemists, in recognition of his services to the profession of chemistry and his activities on behalf of the Institute. Presentation of the certificate was made at the June 3rd meeting of the Chicago chapter.

* * *

E. F. Schwarzenbeck has been appointed director of the Petroleum and Chemical Research Laboratory of M. W. Kellogg Co. at Jersey City.

* * *

Dr. V. I. Komarewsky, professor of chemical engineering at Illinois Institute of Technology, and director of its Catalysis Laboratory, has been invited to speak before the Danish Chemical Society, in Copenhagen, in September, on the subject "Catalytic Reaction of Hydrocarbons".

* * *

J. A. La Fortune, executive vice president and director of Warren Petroleum Corp., and a past president of the Natural Gasoline Assn. of America has been elected a director of the Oklahoma Natural Gas Co.

For Sale

ALL NEW

REFINERY EQUIPMENT

IMMEDIATE DELIVERY

TOWERS —

1—Crude Synthetic Tower, 7′ 6″ I.D. x 85′ 7″ High (Item 9)
1—Salt Neutralizer Tower, 24′ High (Item 47)
1—Stripping Tower, 5′ I.D., 28′ High (Item 1075S)
2—Absorption Towers, 8′ I.D., 34′ High (Item 1076S)
1—Scrubbing Tower, 8′ I.D., 23′ High (Item 1077S)

TANKS —

2—Salt Storage & Pump Tanks 12′ O.D., 60′ Long (Item 8-546)
1—Depropanizer Feed Surge Tank, 8′ O.D., 14′ Long (Item 524)

PUMPS —

2—Molten Salt Pumps, vertical, Ingersoll-Rand size 32, cap.—9000 GPM (Item 25)
2—Molten Salt Pumps, vertical, Ingersoll-Rand size 40, cap.—17,500 GPM (Item 24)
14—Reciprocating Pumps:—(Item 341)
2—8 x 5 x 12—Cap. 30 GPM
2—6 x 6 x 18—Cap. 51 GPM
1—12 x 7 x 18—Cap. 190 GPM
1—6 x 7¼ x 12—Cap. 75 GPM
2—6 x 5 x 12—Cap. 35 GPM
2—6 x 4 x 6—Cap. 15 GPM
2—10 x 6 x 12—Cap. 35 GPM
1—6 x 3¾ x 6—Cap. 26 GPM
1—5¼ x 4¾ x 5—Cap. 32 GPM

TURBINES —

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1—750 HP Terry
1—150 HP Terry
1— 65 HP G.E.
1— 55 HP Terry
1— 50 HP G.E.
2— 24 HP Terry
1—20 HP Terry
1—15 HP Terry
1—15 HP G.E.
1— 9 HP Terry
1— 9 HP G.E.
1— 5 HP Terry
1— 2 HP G.E.

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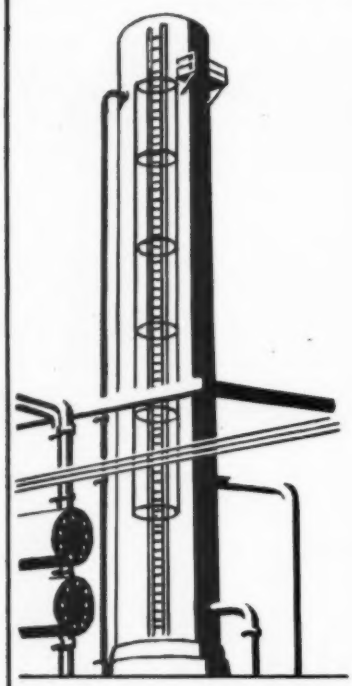

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Your local Oakite Technical Service Representative will gladly help you set up a simple, inexpensive system whereby cleaning solutions are circulated through tower and returned to tank for re-heating and re-circulating. Get in touch with him today or write direct for Digest describing this and 87 other Modern Oakite Ways to save maintenance cleaning time and money.

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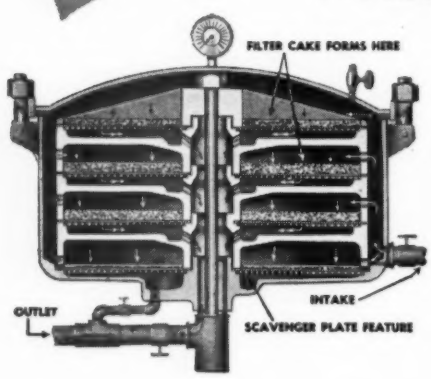
SPARKLER horizontal plate FILTERS

. . . keep petroleum products clean and free of foreign matter



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The petroleum refining and processing industry have available a filter in the Sparkler that solves many problems of keeping liquid petroleum products free from solids such as scale, rust, grit, and other foreign matter.

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Sparkler filters are available in capacities from small pilot plant models to built-in production line units of 5000 gallons per hour. The services of our staff of engineers with over a quarter of a century experience in solving filtration problems is available. Your problems will receive personal attention and individual analysis. Write Mr. W. J. Kracklauer, Sec'y & Treas.

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For Sale

FOR SALE

1—Shriver 42" x 42" Filter Press, 46 chambers, hydraulic closing device.

1—Pfaudler glass-lined Reactor 500 gal., complete with drive and impeller type agitator, Series RS.

BOX 32

FOR SALE

3—International Boilers, Scotch Marine type, 200 HP, 125# Steam Pressure, ASME code, Coal fired.

1—Kewanee Firebox Boiler, "500" Series, Hi Pressure, Heavy-duty, riveted, for Hand Fired coal, 125# steam pressure, ASME code.

BOX 33

MEETINGS . . . for the Oil Man

JULY

27, American Petroleum Institute, Board of Directors Meeting, Washington D. C.

AUGUST

15-17, Society of Automotive Engineers, National West Coast Meeting, Multnomah Hotel, Portland, Ore.

17-Sept. 6, United Nations Scientific Conference on the Conservation and Utilization of Resources, U. N. Interim Headquarters, Lake Success, N. Y.

SEPTEMBER

6-8, American Institute of Chemical Engineers, Regional Meeting, Mount Royal Hotel, Montreal (Que.), Canada.

9-12, Instrument Society of America, Clinic on the Maintenance of Industrial Instruments, Statler Hotel, St. Louis.

12-16, American Society of Mechanical Engineers, Instruments and Regulators Division Conference and Exhibit, Municipal Auditorium, St. Louis, Mo.

12-16, Instrument Society of America, Annual Conference and Exhibit, Municipal Auditorium, St. Louis, Mo.

14-16, National Petroleum Assn., Hotel Traymore, Atlantic City, N. J.

18-23, American Chemical Society, 116th National Meeting, Atlantic City, N. J.

24-27, American Institute of Mining & Metallurgical Engineers, Regional Meeting, Neil House, Columbus.

28-30, American Society of Mechanical Engineers, Fall Meeting, Lawrence Hotel, Erie, Pa.

30-Oct. 1, Colorado School of Mines, Mineral Resources Conference, Golden, Col.

OCTOBER

2-5, American Society of Mechanical Engineers, Petroleum Division, Petroleum Mechanical Engineering Conference, Biltmore Hotel, Oklahoma City.

3-4, National Assn. of Corrosion Engineers, South Central Regional Meeting. Adolphus Hotel, Dallas.

3-5, National Lubricating Grease Institute, Annual Meeting, Roosevelt Hotel, New Orleans, La.

7, California Natural Gasoline Assn., 24th Annual Fall Meeting, Ambassador Hotel, Los Angeles.

10-14, American Society for Testing Materials, First National West Coast Meeting, Fairmont Hotel, San Francisco.

17-21, American Society for Metals, Annual Meeting, Public Auditorium, Cleveland.

17-21, American Welding Society, Annual Meeting, Public Auditorium, Cleveland.

20-21, American Institute of Mining & Metallurgical Engineers, Fall Meeting, Petroleum Branch, Elk's Club, Los Angeles.

26-27, American Society of Mechanical Engineers, Fuels Division Conference, French Lick Springs Hotel, French Lick, Ind.

NOVEMBER

1-5, 2nd Pacific Chemical Expo, San Francisco Civic Auditorium, San Francisco.

3-4, Society of Automotive Engineers, Fuels & Lubricants Meeting, Chase Hotel, St. Louis, Mo.

7-10, American Petroleum Institute, Annual Meeting, Stevens Hotel, Chicago.

27-Dec. 2, American Society of Mechanical Engineers, Annual Meeting, Hotel Statler, New York.

DECEMBER

4-7, American Institute of Chemical Engineers, Annual Meeting, William Penn Hotel, Pittsburgh.

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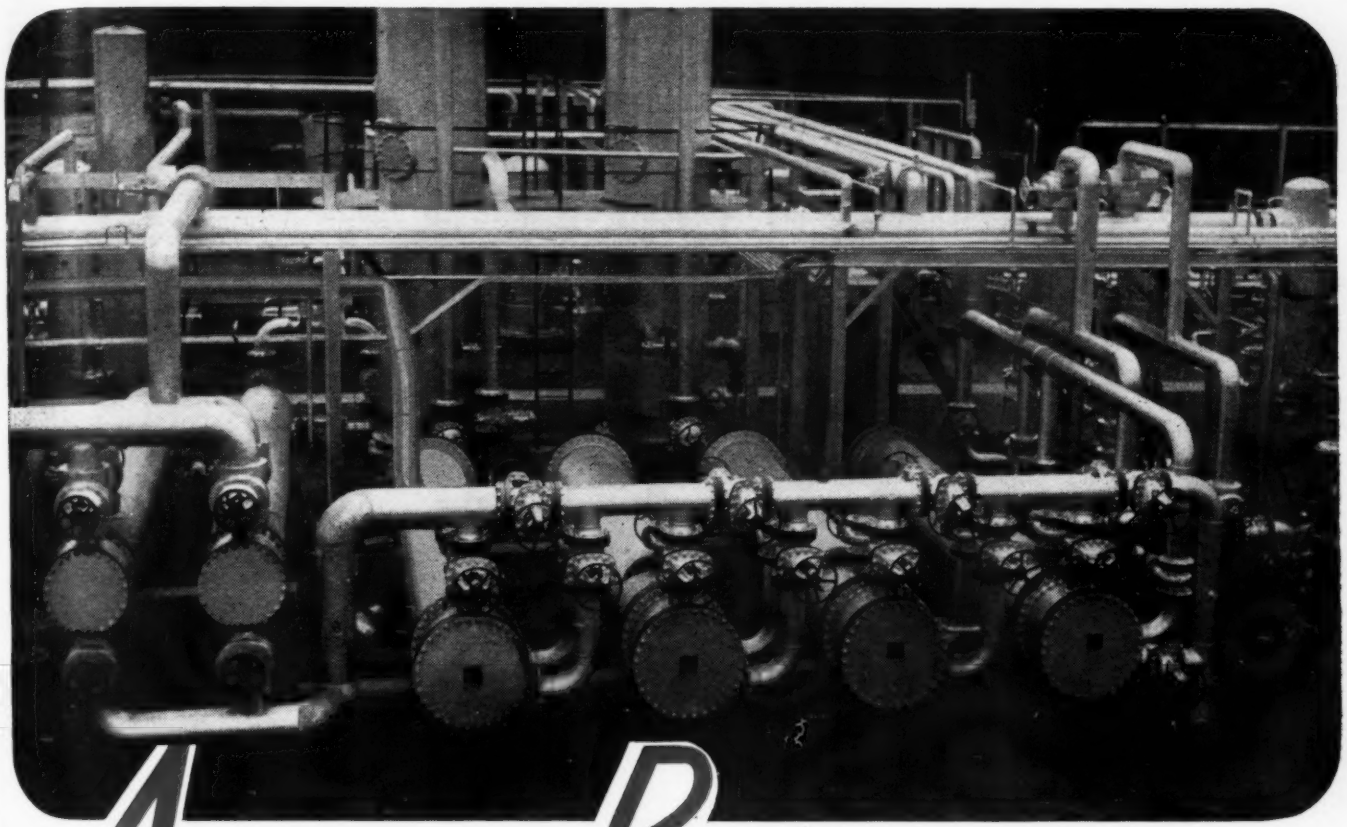

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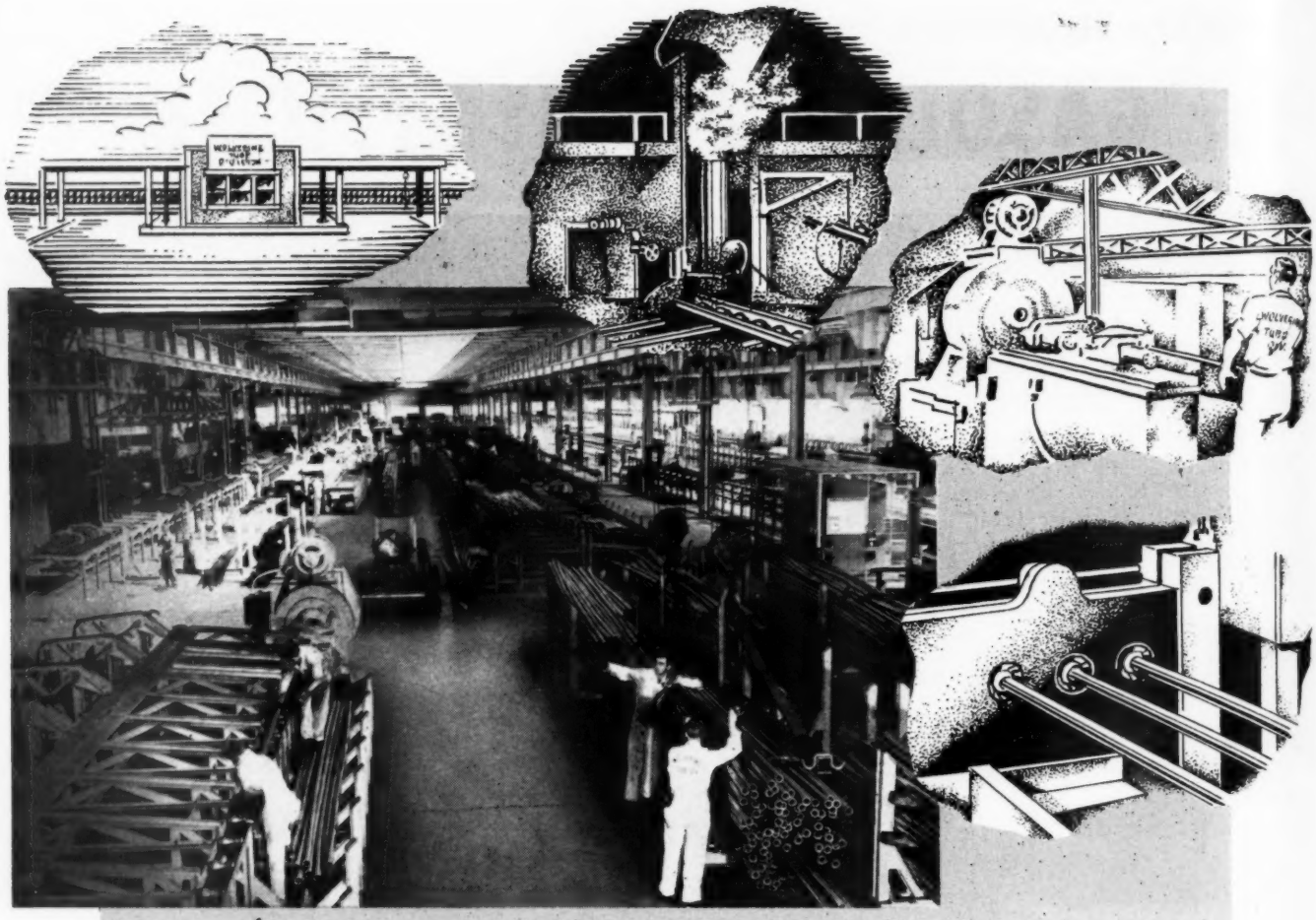

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EDITORIAL VIEWPOINTS...

Opinions and Comments on Current Topics

Need More Emphasis on Petroleum Research, Less on Synthetics

THE great amount of promotion publicity given the synthetic liquid fuels research program of the Bureau of Mines has distracted attention from the long-established studies of the Bureau in the petroleum and natural gas field, which have been of direct and practical value to the oil companies.

It has now been definitely established that the nation's liquid fuel needs can be adequately supplied from petroleum alone for as far into the future as can be foreseen. This fact in itself removes the chief argument for the intensified synthetic fuels program inaugurated by the Bureau six years ago, through direct legislation by Congress. By virtue of present circumstances, its work relating to improved methods of recovery of petroleum from the ground, and of processing crude, should be reappraised and expanded, if necessary, and that in the synthetic field de-emphasized.

The Bureau already has an extensive background of experience in the petroleum and natural gas fields. For some 30 years its engineers have been studying the structure, pressure and water conditions in many oil pools. Their reports aided the oil companies in the more efficient operation of their producing properties there. More recently this agency has done a good deal of work on methods of secondary recovery from oil fields formerly considered exhausted. In the field of refining, important studies are now being carried on in the handling and processing of high-sulfur crudes, a subject of growing importance to refiners today.

The work of the Petroleum and Natural Gas Branch of the Bureau has been done at only a small fraction of the annual cost of the highly exploited synthetic fuels research program. Its entire appropriation from the regular funds appropriated for the Bureau's work, for the fiscal year ending June 30, was $606,000. This covered its investigations in such fields as; primary extraction of crude oil and natural gas; secondary recovery and development of oil-impregnated surfaces; transportation and storage of oil and gas; chemistry and refining of petroleum and the thermodynamics of petroleum. It also covered the cost of operating the Bureau's principal petroleum experimental station, at Bartlesville. In addition, this year the Petroleum and Natural Gas Branch received about $300,000 from the funds appropriated for the synthetic liquid fuels program, for expansion of production research in secondary recovery methods and in refining processes.

By comparison, here is what the Bureau's synthetic fuels program is costing the public. Congress authorized the expenditure of $60,000,000 over an 8-year period now in its 6th year. A total of $34,000,000 has already been appropriated and a request for $4,400,000 more to meet obligations incurred under contract authorization is now pending in Congress. The Bureau of the Budget has approved $10,000,000 for the fiscal year 1950.

It will be difficult indeed to call a halt to the Bureau's synthetic liquid fuels research program. Pressure from various sources will be exerted on Congress to renew the large appropriations granted for the present work, even though there no longer exists any immediate need for its findings.

If Congress is to be informed of the need for a reappraisal of the work the Mines Bureau is carrying on in the synthetic fuels field and in the straight petroleum and natural gas field, in the light of present day conditions, the story will have to come mostly from the technologists and others in the oil and gas industries. It is a task they should not hesitate to undertake.

Taking It from the Wrong Pocket

THE INDICATED RATIO of yield of gasoline to crude runs to stills in U. S. refineries currently is reported to be over 44%, the highest on record. The actual rate of output in March, the latest published figure as this is written, was 42.48% and study of the API weekly refining reports shows the rate of output has gone higher in recent weeks.

The highest rate for gasoline output reached in 1948 was about 41.5% and this was in the later months. The rate of output in the early months of last year was between 38 and 39%.

Achieving this high current rate of gasoline manufacture has enabled refiners to produce some 17,000,000 barrels more of this product in the first quarter of 1949 than in the same period in 1948, which also had an extra day due to Leap Year, a percentage gain of 8.3%. This increased production was gained while running only about 5,500,000 barrels more crude to stills than in the corresponding period in 1948.

The great part of the gain in gasoline output this year has been at the expense of gas oil and distillate fuel production, which was about 8,000,000 barrels less in the first three months of 1949 than of 1948. There has been a decrease of only about 1,000,000 barrels, less than 1%, in residual fuel oil production for the 1949 first quarter.

The gasoline production picture thus far in 1949 might be very different had not the light winter and resulting abnormally low consumption of heating oils enabled refiners to convert into gasoline large volumes of material that otherwise would have gone into distillate fuels to meet last winter's requirements. Higher crude runs to stills probably would have been necessary to meet this year's growing gasoline demand.

The refiners have shown their ingenuity and the flexibility of their operations in thus converting a current surplus of distillate oils into motor fuel. However, apparently there is a long way to go in developing and applying methods for converting residual fuels into gasoline and other light products, which long-term economics indicate is a sounder procedure. Processes to this end are in the making and are being applied in a few large refineries.

It is misleading to assume, from the present record rate of gasoline output to crude runs to stills, that we are already drawing increased gasoline production from the residual fuel oil pocket.

CHEMICAL USERS' GUIDE

to General Chemical Products for the Petroleum Industry

ALKYLATION

ANHYDROUS HYDROFLUORIC ACID
Grades or Strengths: 99.0% HF min. (one grade only)
Packing: Steel Cylinders, Tank Cars

SULFURIC ACID
Grades or Strengths: Standard
66° Baume—93.19% H_2SO_4
99% H_2SO_4
Diamond—66° Baume
Crystal—66° Baume
Packing: Tank Barges, Steel Tank Cars, Steel Tank Trucks, Steel Drums, also Carboys

POLYMERIZATION or ALKYLATION

FLUOSULFONIC ACID—$HO{:}SO_2F$ (HSO_3F)
Grades or Strengths: Min. Content 98% Fluosulfonic Acid
Packing: Steel Tank Cars, Steel Drums

BORON TRIFLUORIDE
Gas: Cylinders
Ether Complex: 47.88% min. BF_3. Packing: 5, 20 and 55 Gal. Drums
Phenyl Complex: Drums
For Bulk Quantities write Baker & Adamson Products, General Chemical Division, Allied Chemical & Dye Corporation, 40 Rector St., New York 6, N. Y.

SULFONATION

SULFURIC ACID

SULFAN "B" (Stabilized Sulfuric Anhydride)
Grades or Strengths: 99% SO_3 min.
Packing: 55 Gal. Drums

OLEUM
Grades or Strengths: 15% free SO_3 (103.38% H_2SO_4)
20% free SO_3 (104.5% H_2SO_4)
65% free SO_3 (114.38% H_2SO_4)
Packing: Steel Drums, Tank Cars, Tank Barges, Tank Trucks

ISOMERIZATION

MURIATIC ACID (Hydrochloric)
Grades or Strengths: Standard—18°, 20°, and 22° Baume
Packing: Rubber-lined Tank Cars, Rubber-lined Tank Trucks, also Carboys

DETERGENTS & BUILDERS

SODIUM METASILICATE
Grades or Strengths: Granular, thru 10 mesh; Powdered, 90% thru 40 mesh
Packing: Multiwall Paper Bags, Fibre Drums

DISODIUM PHOSPHATE
Grades or Strengths: Anhydrous
Packing: Multiwall Paper Bags, Fibre Drums

SODIUM SULFATE, Anhydrous
Grades or Strengths: Standard, approximately 99.5% Na_2SO_4
Packing: Multiwall Paper Bags

TRISODIUM PHOSPHATE
Grades or Strengths: Coarse, thru 10 on 20 mesh; Medium, thru 20 mesh on 100 mesh; Standard, thru 20 mesh, 15-25% thru 100 mesh; Fines, thru 40 mesh, 50% thru 100 mesh
Packing: Multiwall Paper Bags, Fibre Drums

TETRASODIUM PYROPHOSPHATE
Grades or Strengths: Anhydrous, Powdered, 100% thru 20 mesh, 90% min. thru 100 mesh
Packing: Multiwall Paper Bags, Fibre Drums

ACIDIZING

MURIATIC ACID (Hydrochloric)
HYDROFLUORIC ACID

MUD CONDITIONING

SODIUM SILICATE
Grades or Strengths: Clear and Opalescent Grades in a wide range of viscosities ranging from 38° to 60° Baume
Packing: Steel Drums, Tank Cars, Tank Trucks

DISODIUM PHOSPHATE
TRISODIUM PHOSPHATE
TETRASODIUM PYROPHOSPHATE (TSPP)

OTHER CHEMICALS

Aluminum Sulfate, Standard & Iron Free
Aqua Ammonia
Sodium Fluoride
Nitric Acid
Potassium Nitrite
Other Heavy Chemicals

CATALYSTS and SPECIAL CHEMICALS

Companies requiring catalysts, addition agents, inhibitors, or other special chemicals "tailor-made" for their individual processes are invited to consult with General Chemical on their requirements. The same progressive research, technological "know how," and practical experience that has found the answer to so many petroleum chemical problems during General's long service to the Industry may help provide the solution to yours, too.

The products advertised herein are commercial chemicals having various uses, some of which may be covered by patents, and the user must accept full responsibility for compliance therewith.

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FOR AMERICAN INDUSTRY

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CHEMISTRY AT WORK

Fractionating Towers, fabricated by WYATT'S exacting workmanship, helping to produce organic chemicals from Propane and Butane gases.

Wyatt's

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